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EDITORIAL

YIELD PREDICTION IN HEVEA

The article by Mr. Gunnery contains the results to date of investigations in progress at the Institute, which constitute a part of the programme of work on the physiology of latex production. The particular aspect of the problem dealt with is the correlation of anatomical structure of the latex-bearing tissue with yields.

It will be recalled that several previous attempts to correlate the structure of the latex-bearing tissue with yields have been made, notably the work of Ashplant in which yield was stated to be directly related to the diameter of the latex tubes. Considerable doubt has, however, been cast on the Ashplant theory, which has not been confirmed by subsequent investigations. It would also appear likely that the problem of yield is not so simple as that stated by Ashplant, and that the structure of the tissue surrounding the latex tubes in which other constituents from which latex is synthesised are elaborated probably has a considerable influence on yield, that is to say, the Ashplant theory is only the partial truth.

While admitting that further investigation is required to confirm the result now given, it appears desirable to publish those already obtained.

Apart from the value of this investigation on the complex problem of the physiology of latex production, the value of some method of examination of planting material at the earliest possible stage, in order to be able to predict yield or to select high-yielding material, is obvious. Methods so far adopted for this purpose include various pricking systems of nursery plants and early "test-tapping" of plants at about three years of age. The value of these methods has not yet been definitely proved.

For carrying out the technique of the method described in the present article a trained microscopist would be essential, but the cost of selection of high-yielding material would probably be amply justified by the results obtained.

It will be observed that while low-yielding planting material would be rejected, the correlation is not sufficiently good in the case of medium-yielding material, which indicates that some other factor influencing yield is probably present. The elimination of low-yielding material is, however, of considerable value for selection work.

Mr. Gunnery is to be congratulated particularly on the excellence of his technique and the micro-photographic reproductions of the sections.

Selection of Planting Material

The article by Mr. Mann on "Recent Progress in the Selection of Planting Material of Hevea" formed the subject of a lecture given by him recently before the combined Nilai and Rantau branches of the Incorporated Society of Planters.

In view of the numerous enquiries addressed to the Institute during the year on the subject of the value of clonal seed for planting purposes, it appears desirable to publish this lecture in order to indicate the opinion of the Institute on the value of high-yielding material at present available for planting.

There is still a conservative body of opinion in planting circles which is not in favour of budgrafting and which has a lurking idea that the exponents of budgrafting are not fully convinced as to the value of this method of developing high-yielding areas and for that reason are "hedging" by experimenting on seed selection. It appears necessary therefore to emphasize that these two methods of developing high-yielding material must go hand in hand.

It is obvious that when "reliable" high-yielding selected seed is available in sufficient quantity this will prove more economical for planting than the operation of budding. *At the present time, however, no "selected" seed is available which has been proved capable of producing trees having as high a yield as the best budded material at present available.*

It has not yet been proved that the seed obtained by the crossing or selfing of all high-yielding clones will give high-yielding progeny. It appears more probable that only certain families of crosses may prove especially valuable, such as the crosses of high-yielding clones with A.V.R.O.S. 157. Some crosses made at the Institute Experiment Station indicate that similar high-yielding progeny can also be raised from crosses of high-yielding clones with Pilmoor clone A. 44.

It is fortunate that the Institute has a certain amount of material available for experimental purposes which was developed

before the retrenchment of staff in 1932, when the policy recommended and adopted by those controlling the Institute's activities was to cease all work on "seed selection" for *problems of more immediate importance.* It is interesting to note that it is now considered the most important problem in the research programme of the Botanical Division, with which the writer is in entire agreement.

Smoke-House for Small-Holders

The erection and equipment of cheap factories and smoke-houses for small-holders is a problem of considerable importance.

There is no reason why the small-holder who owns only two to three acres of rubber in tapping should not produce sheet rubber which is equivalent in all respects, *i.e.* in appearance and in those properties desirable for manufacturing purposes, to that prepared on any large European estate with the most modern equipped factory and smoke-house. All that is necessary is care and cleanliness.

The more important problem from the point of view of the financial benefit to the small-holder is the production of *dry* sheet rubber, which should preferably be smoked. By selling wet rubber the small-holder loses money and this loss is still greater during the present period of rubber regulation, when the small-holder hands coupons for wet rubber which he sells to the local dealer.

It is considered, after trials carried out at the Institute, that the smoke-house described is eminently suitable for small-holders on account both of its cheapness and efficiency. The development and application of this smoke-house is one indication of the value of the Small-Holders' Advisory Service inaugurated in 1934.

A number of these smoke-houses have already been erected at suitable centres throughout Malaya and demonstrations have also been carried out at all the District Agricultural Shows held during 1935.

Reprints of the article describing the smoke-house are available and arrangements have already been made with the Department of Agriculture to translate the article into Jawi and Chinese for publication in the vernacular Journals issued by the Department for distribution among small-holders. Propaganda has also been effected by means of the Rural Lecture Caravan.

Deterioration of Rubber by Manganese

The article on this subject by Mr. Hastings and Dr. Rhodes, although it concerns only what we consider as one of our minor

items of research, is of particular interest for several reasons. In the first place it illustrates the importance of liaison of producers' research organizations with the rubber manufacturer; secondly, it illustrates the importance of knowing the origin of a particular sample of rubber, since this was of much value in tracing the cause of the deterioration of the rubber; thirdly, it is of interest in that, had this particular consignment of rubber not been stored for a prolonged period, the deleterious effect of the manganese would probably not have been discovered, although certain rubber articles manufactured from this and subsequent consignments would possibly have aged or perished badly; while fourthly, it confirms our previous condemnation of the use of soluble manganese compounds in the treatment of raw rubber. (Note:—A few years ago we had to condemn a local process for the preparation of an imitation smoked sheet on account of the fact that the product contained potassium permanganate. Potassium permanganate has also been used occasionally as a disinfectant or fungicide for the treatment of sheet rubber but its use for this purpose must be condemned).

In the case under discussion the manufacturing firm concerned thought that manganese salts had possibly been used in the treatment of the rubber, whereas it was possible to trace the manganese to a peculiar water supply used on the estate from which the rubber was purchased. Normally, as is pointed out in the article, Malayan water supplies contain very small amounts of "total solids" in solution—the amounts being usually below ten parts per 100,000. The particular supply on this estate not only contained a very high proportion of soluble mineral solids but nearly 25 per cent of this consisted of manganese. Fortunately the estate in question has been able to utilize alternative sources of water and has discarded the supply containing this abnormal content of manganese.

Manganese, like copper, although to a lesser extent, acts as a catalyst in causing oxidation of raw rubber, producing tackiness. Even, however, if the amount of manganese present may not cause actual tackiness in the raw material, the manufactured rubber articles may age badly.

Brass Wire Gauze Strainers

It has long been known that copper salts have a very deleterious effect on raw rubber, causing the rubber to become "tacky". In some cases the rubber may be converted into a pasty fluid and eventually into a brittle "resin". Copper salts act as a catalyst in accelerating oxidation of the rubber, the oxygen being absorbed

from the air. Although very minute quantities of copper in raw rubber may not cause "tackiness" until the rubber has been stored for a period, *it may still cause any vulcanized articles made from such rubber to age badly, i.e. to perish rapidly.*

As a result of the exhibition of a brass wire gauze sieve at the Rubber Exhibition held under the auspices of the Rubber Growers' Association, London, at the Science Museum, South Kensington, it appears to have been realized for the first time by certain authorities at home that such sieves are being used in estate factories in the East. We have therefore been asked to draw attention to the deleterious effect of brass or copper in contact with latex or raw rubber and to discourage the use of such sieves.

The article discusses the present situation and the possibilities of substitutes for brass wire gauze, and indicates that investigation is in progress at the Institute with the object of finding a suitable substitute. *Special attention is drawn to the danger of straining ammoniated latex through a brass wire gauze sieve.*

Oidium Heveae in 1935

The article by Mr. Beeley describes the situation in respect of the incidence and virulence of Oidium leaf disease during the refoliation period after wintering in the present year. Owing to the more favourable climatic conditions, both the incidence and virulence of the disease were considerably less than in 1933 or 1934. The effect of sulphur dusting in relation to the improvement of foliage was therefore not very evident.

In view of the fact that some Directors of rubber companies at home appear to consider (a) that the Institute is not so familiar with this disease and its effects as the authorities in Ceylon and (b) that sufficient attention is not being paid to its control, it appears desirable to draw attention to the different factors in Ceylon and Malaya which affect the incidence and virulence of the disease. These may be summarised as follows:—

In Ceylon and in Java, as compared with Malaya, the worst attacks are on areas above 1,000 ft. where (a) the temperature is cooler (b) the humidity is higher during the day and lower at night (c) the soils are poorer (d) the general vigour of the trees lower (e) recovery from leaf-fall is slower (f) foliage is generally poorer (g) weather conditions generally favour the development of the disease while in Malaya they favour the rapid growth of the new leaf and are detrimental to the fungus.

Sulphur dusting is recommended in all cases as the most effective treatment. Manuring is a complementary measure to improve foliage when leaf-fall is intensive, but is not a cure or a

prophylactic in the absence of sulphur dusting. Deterioration of foliage and bark renewal generally in Malaya is due to soil deterioration caused by prolonged clean-weeding and the lack of manuring, until recently, and not to leaf-fall caused by Oidium leaf disease.

Although it cannot be stated with certainty, it is probable that the larger number of cases of secondary leaf-fall reported during 1935 is due to the fact that a circular, requesting the manager to report cases of leaf-fall and to send specimens of leaves for diagnosis if necessary to the Institute, was issued to every estate early in the year.

Hevea Thrips

A new pest of the rubber tree caused by a small insect of the Thrips species is described by Mr. Beeley.

This insect was discovered on the Institute Experiment Station for the first time in 1935 where the leaf-fall on late-wintering trees was at first considered to be due to Oidium leaf disease. The effect of the attack on the leaf resembles that caused by the mite *Tarsonemus translucens* and is generally distinguishable from Oidium attack by the curvature of the attacked leaf. It has also been established that this insect was responsible on some estates for leaf-fall attributed to Oidium. On the Experiment Station, it was particularly virulent on late-wintering trees, *e.g.* Clone AVROS 50, on an area on which eight other clones, planted at exactly the same time, which wintered early, were free from attack.

The method of control recommended is similar to that for Oidium, although the admixture of a copper compound dust with the sulphur will probably be more effective.

The Use of Natural Covers on Rubber Estates

The article on this subject is published with the object of clarifying the somewhat confused ideas which appear to be held at present by many planters and others on the problem of soil regeneration by the encouragement of natural undergrowth on estates.

Few planters appear to realize the significance of the term "Ecology" (or "Œcology") which, as is pointed out, is a branch of the science of botany and therefore related to both agriculture and forestry.

(Note:—Ecology also embraces the study of animals in relation to their environment, so that as applied to plants, the term "Plant Ecology" is more appropriate and is frequently used).

The soil factor concerned in the study of ecological problems is termed the "Edaphic factor" and embraces the whole study of soil science in relation to plant growth. The other factors are climatic, physiographical (topography etc.) and biotic (the influence of animals and man on natural vegetation). It is obvious therefore that the problem primarily concerns the soil scientist and the botanist (if we desire to make classifications) whether they are concerned with agriculture or forestry.

Much of general scientific interest could be written on this subject and the existing literature is already considerable. In 1926 in a preface to a book entitled *Aims and Methods in the Study of Vegetation* the authors (one of whom is A.G.T.) write "Partly because the field of vegetation study is so vast and can be usefully attacked in so many ways, partly because the study is still so young and relatively undeveloped, *no completely uniform and systematic treatment of field methods can be written.*" This applies particularly to the study of the natural vegetation of areas undisturbed by man for agricultural purposes. When the study is applied to the regeneration of soils deteriorated by the agency of man or animals (grazing areas) the problem is still more recent and difficult since Man is expected to effect improvements in less than a decade, which Nature has taken perhaps thousands of years to effect.

The Sakai and other aboriginals with their shifting cultivation were obviously aware of the rapid deterioration of soils by the destruction of forest for the planting of foodstuffs.

The above is written to indicate that this problem is not so simple as one might be led to infer by those who step in "where angels fear to tread" and that several decades will probably pass before the value of any systematic methods of treatment recommended can be proved.

YIELD PREDICTION IN HEVEA

A Study of Sieve-Tube Structure in relation to Latex Yield

BY

H. Gunnery

Introduction

It may be generally conceded that the tapping test provides the most efficient method for the assessment of yield capacity in Hevea. Its application is unaccompanied by any technical difficulties or ambiguity in interpretation, while the results achieved are conclusive. Unfortunately, however, its application is restricted entirely to the period when the latex system is sufficiently developed to permit of effective comparison and a period of seven years or more must elapse before these conditions are satisfied. The inherent defect of the method is the time factor and it will be evident therefore that, until some alternative method is evolved whereby the potential yield of Hevea can be forecast at an earlier stage, progress, not only in the production of new and better clones, but in the possibly more fertile field of genetics in relation to this plant, will be seriously impeded.

The limitations of the test-tapping method have long been appreciated and several attempts have already been made to exploit certain factors present in the young plant. These investigations have been summarised elsewhere (1) and as the results were inconclusive no useful purpose would be achieved by discussing them in further detail.

As indicated above the solution of the problem is entirely dependent on the presence of some measurable character or factor in the young plant. The plant body is essentially a congeries of interacting cell units adjusted to the performance of its varied life functions, of which latex production is but a single expression in the general metabolism. The fact, however, that high yield is in some measure associated with the presence of an increased number of latex rings suggests that this general metabolism may be influenced or even controlled by a specific cell organisation or, in other words, that structure and function are correlated. Such a conception is of value for the purpose in view, for if such a correlation can be demonstrated it may be expected that any increase in the latex-tube complement will of necessity involve some modifications in the accessory structures associated with it. Whatever purpose latex may serve in plant economy it is reasonable to suppose that any increase in its volume connotes an increased

rhythm in the general metabolism, accompanied by a more rapid transport of water and solutes from the soil and elaborated constituents from the leaves. If then these increased activities are indeed reflected in a correlated modification of some factor or factors in the transporting system, it remains only to ascertain the degree of correlation in order to provide data from which the potential yield could be predicted.

It must, however, be stressed that the production of latex is entirely a function of living cells, subject to the limitations imposed by numerous known or obscure internal and external influences. It is improbable, therefore, that a system of analysis founded on anatomical data alone can serve to differentiate between the relative merits of trees belonging to a high-yielding category. If, however, the anticipated correlation can be definitely established, the identification of inferior or low-yielding individuals by such a method should impose no insuperable difficulty, and it is in view of the latter contention that the present investigation was undertaken.

To understand clearly the significance of the sieve-tubes in the present investigation, it is desirable to form a mental picture of the channels through which the transport and interchange of food materials is accomplished. Before proceeding, therefore, to the examination of the results achieved, the following brief outline of the origin and development of the vascular system in plants in general, and their organization and relationships in Hevea in particular, may serve this purpose.

General Anatomy

In plants of simple structure, and in embryonic tissues of all higher plants, the transport of food materials is accomplished by the relatively slow process of diffusion from cell to cell. With increasing complexity in organisation this method is supplemented by the development of a vascular system which, extending throughout the entire body of the plant, provides greatly enhanced possibilities for the rapid transport of materials in any direction.

The fundamental unit of the vascular system is the **vascular bundle,** a composite structure of three structurally and functionally different elements. Of these the outer and inner structures are known as the **phloem** and **xylem** respectively, each of which contains functionally appropriate conducting vessels embedded in accessory tissues. Between these two conducting strands lies the third unit or **vascular cambium,** a narrow band of undifferentiated cells which, by their inherent capacity for unlimited division, provide the mechanism for the further growth of the vascular bundle.

In herbaceous plants the vascular bundles are arranged concentrically in such a manner that the stem, viewed in transverse section, is divided by a ring of separate bundles into a central region or **pith** and an outer region or **cortex,** the outer surface of which is protected by a tough skin or **epidermis.** The strips of tissue lying between the bundles and thus connecting the inner and outer regions form the **primary medullary rays.** This primary differentiation of the stem, in which a central pith is enclosed by an interrupted vascular cylinder bounded by a cortical envelope or sheath and with intercommunicating medullary rays, represents in varying degree the final organisation in the stems of all herbaceous plants. In Hevea, as in all arboreal types, however, it is the prelude to a further series of growth phenomena whereby the more complex architecture of the latter type is finally evolved. This second phase in development is initiated by further growth and extension of the cambium. In the primary condition as already described the cambium is confined to the vascular bundle between the phloem and xylem and bounded radially by the strips of tissue—the medullary rays. By the division of a line of the latter cells contiguous to the cambium, new segments of cambial tissue are differentiated which, bridging the medullary gaps, result in the formation of a continuous cambial cylinder. The stem is now completely divided into an outer region of phloem and cortex and an inner region of xylem—or wood, and pith. The establishment of the cambium cylinder is the starting point for all subsequent growth; from its inner face are derived all the woody fibres and vessels which constitute the woody cylinder, while from its outer face are differentiated the various tissue elements of the phloem or 'bast'. Meanwhile in the outer part of the primary cortex a second cambium, the **phellogen,** makes its appearance. Its activities, of a less protean character perhaps than those of its predecessor, result in the formation of an impermeable corky layer on the outside, while at the same time contributing further increments of cortical cells from its inner face. With increasing maturity stone-cells are evolved by heavy lignification of groups of cortical cells to form the main mechanical support of the bark. The stem now consists of two distinctive parts, a cylinder of wood derived entirely from the inner face of the cambium and an outer covering of 'bark' of twofold origin—the inner part or soft bast of vascular cambial origin and an outer part derived from the cork cambium or phellogen. The establishment of these two meristematic layers provides the mechanism for all subsequent growth of the stems.

It will be observed that the once-isolated conducting strands or vascular bundles have now been resolved into concentric and

contiguous cylinders, the inner xylem or wood devoted to the conduction of water and soil solutes and an outer phloem or bast for the translocation of elaborated compounds from the leaves. Between them lies the thin line of cambium from which successive increments of wood and bast are added to meet the ever-increasing demands imposed on the vascular system. (Plate 1)

The Phloem

The phloem or bast is the main channel for the transport of plastic food materials elaborated in the leaves. It is a somewhat complex tissue of varying cell types, all having a common cambial origin. The most important constituents are the sieve tubes, which are formed by the longitudinal fusion of rows of elongated cells, with oblique partition walls on which are developed a varying number of perforated areas known as the sieve plates. The tubes are lined with a thin layer of cytoplasm or living substance which, passing through the perforations of the sieve plates, maintain a living connection throughout its entire length. In the active state they are filled with a liquid containing the food substances either in solution or in a fine state of suspension. The sieve tubes are distributed in varying number and pattern in a non-tubular ground tissue of more or less elongated cells—the phloem parenchyma. The function of these cells in conjunction with the medullary-ray system, is concerned largely with the radial transport and storage of food materials received from the sieve tubes and water with soluble mineral food material from the wood. The medullary rays are common to wood and phloem and consist of radially-disposed plates of tissue running from the cambium inwards into the wood and outwards through the phloem thereby bringing into intimate anatomical relationship the contiguous conductive tissues of wood and phloem. (Plates 2, 9 and 10)

Latex System

In latex-producing plants, whether herbaceous or arboreal, the tissue organisation so far described is accompanied by the development of a system of either cells or tubes containing the characteristic substance, latex, the chemical constitution of which varies considerably in the various species of the group. In all cases however the main bulk of the latex consists of substances such as caoutchouc and resins, which appear to be incapable of further metabolism. For this reason the relationship between the latex vessels and the vascular system has not yet been clearly established.

In the young seedling of Hevea the latex vessels form a network in the primary cortex of stem, root and branches, accompanying the vascular strands through the petiole and leaf veins, forming a primary latex-vessel system throughout the young plant. They take their origin not by cambial activity but by the fusion of cell rows of the ground tissue. With the beginning of secondary thickening, following the establishment of the cambial cylinder, a secondary latex system is evolved. In this system the vessels are derived entirely from the outer face of the cambium with the other units of the phloem. Each phloem increment contains its quota of latex vessels and, as growth proceeds, the latex system resolves itself into a series of concentrically arranged cylinders of anastomising vessels embedded in the inner bast. It is from this system that the latex crop is ultimately derived.

Material and Methods

To ascertain the extent to which the anticipated variation in the sieve-tube system of Hevea occurs, a range of bark samples were obtained from a block of 200 six-years-old seedlings at the R. R. I. Experiment Station (Block 2) whose yields varied from 2 lb. per annum in the lowest-yielding class to as much as 25 lb. per annum in the highest. These yields were calculated from the results of test tappings carried out in the months of June and July, 1934, only, although the trees had been test-tapped at intervals of six months for a period of three years. For the present purpose the calculated annual yields are of less significance than the demonstration of the fact that the relative yields had been maintained throughout the test period of three years. Bark samples were also obtained in triplicate from budded trees of 70 established high-yielding clones of varying age categories, and from 200 two-years-old trees of unproved Malayan clones (Block 15). The samples were taken at a uniform height of 50 inches by means of a one-inch diameter cork-borer and placed immediately in a solution of Formol-alcohol for two or three days and then transferred to 70 per cent. alcohol. For the study of the sieve tubes, transverse sections were made by microtome, stained in aniline blue, haematoxylin or bismark brown and subsequently mounted in canada balsam. For the latex tubes, both transverse and longitudinal sections were examined in glycerin after staining in either a 0.2 per cent solution of osmic acid or a strong alcoholic solution of sudan 3. By either of these methods the latex tubes are sharply differentiated from the adjacent tissues. For rapid identification of the sieve tubes thin sections may be obtained with the aid of an ordinary razor and examined in water under a magnification of 100 diameters.

Analysis of the Sieve-Tube Complement

To enable the non-botanical reader to appreciate more readily the results obtained, a series of micro-photographs are presented which display at a glance the characteristics of the sieve tubes as seen in transverse section in trees belonging to definite yield categories. On the basis of the speculations developed in the introduction it is to be expected that variations in the development of the sieve-tube system will be found to occur on the assumption of a potential increase in efficiency as higher yields are attained. It follows therefore that a maximum divergence should be observable if the sieve tubes of the lowest and highest yielders are compared. In Plates 3 and 5 are reproduced 20 examples of the sieve tubes of trees yielding below 2 lb. per annum. Plates 4 and 7 contain similar examples of established clones whose recorded yields vary from 15 to 30 lb. per annum at the tenth year. It will be observed that the sieve tubes of the latter are, in relation to the cells of the ground tissue in which they are embedded, of large size and closely aggregated between the plates of the medullary rays; their mean diameter is 0.04 mm. On the other hand the sieve tubes of the low yielders (Plates 3 and 5) are of such small dimensions that in many instances their identity is lost in the ground tissue. Thus far the results are in complete accord with anticipation. Calculation of the total cross-sectional area of the respective sieve-tube systems indicates that the characteristics of high and low yield appear to be correlated with the extent of development of the sieve tubes. On this interpretation it would be reasonable to expect a co-ordinated response in the latex system itself, for high yield should obviously demand a more highly developed latex organisation. The latex vessels of twenty bark samples of low and high-yielding type were examined, with results in complete agreement with this expectation. Plates 9 & 10 reproduce bark samples from trees Nos. 120 and 512, six-years-old seedlings, yielding 1.7 lb. and 13.2 lb. per annum respectively. The latex tubes are stained orange. Although the low-yielding tree is endowed with an extra ring of latex vessels it will be at once apparent that the total cross-sectional area of the latex-vessel system, and therefore the capacity, is strikingly inferior to that of the high-yielding individual. It would appear indeed, that the respective diameters of the latex tubes are directly proportional to those of the sieve tubes associated with them. The evidence for the persistent and uniform association of large-bore sieve tubes with high yield was further amplified and confirmed by the results obtained from the remaining high-yielding seedlings (Block 2), yielding from 10 to 25 lb. per annum and from the 200 two-years-old "unproved" Malayan

clones (Block 15). The absence of yield records in the latter group precludes individual analysis, but it may be reasonably assumed that, as the mother trees were selected on the basis of a five-fold superiority over the mean of the area concerned, the clones will on the whole possess the high-yield factor. Allowance must be made, however, for the inclusion of trees giving abnormal yield through the incidence of root disease. The results conformed to the general expectation, 39 of the seedlings and 90 per cent of the trial clones possessing sieve tubes comparable with those of the established proved clones.

It remains to examine in detail 120 trees of Block 2 with yields extending from the borderline of the low-yielding type to a maximum yield of 9 lb. per annum. The sieve tubes were broadly of the two distinctive types previously associated with low and high yields respectively but their distribution per unit area varied considerably and proved in consequence a valuable means of analysis.

In Table 1 the trees are assembled in groups according to yield and analysed on a basis of the four grades indicated at the head of the table.

TABLE 1. *Comparison of sieve-tube development in 120 trees yielding from 4 lb. to 10 lb. per tree per annum.*

Grade 1 Poor development
„ 2 Moderate
„ 3 Good
„ 4 Very good, i.e. comparable with high yielding clones

Group	Yields in lb. per tree per annum	Grade				Total trees
		1	2	3	4	
1	4 - 5 lb	15	10	6	—	31
2	5 - 6 „	11	14	9	7	41
3	6 - 7 „		1	11	9	21
4	7 - 10 „	1	1	10	15	27
		27	26	36	31	120

Examination of the disposition of the trees under the four grades reveals a somewhat anomalous departure from the results

previously obtained. With three exceptions the trees of groups 3 and 4 conform to the expected large-bore type of sieve tube but the lower-yielding groups 1 and 2 present a diversity of type inconsistent with the general thesis which implies that the sieve tubes should conform to type throughout the groups. The only alternative explanation connotes a random distribution, divorced from physiological concept, but to be effective such a theory must be equally valid for the whole of the material examined which is obviously not the case. The problem must therefore be amenable to a physiological interpretation consistent with the evidence previously obtained.

In the absence of concrete data it is difficult to avoid the conclusion that the trees in groups 1 and 2 may not possess the homogeneous yield characteristics suggested by the test tapping record. If this should prove the case a subsequent increase in yield performance in those trees of grades 3 and 4, possessing the type of sieve tubes associated with high yield, would at once transfer them to groups 3 and 4, a position that would be in accordance with general expectation.

A decision must therefore be postponed until the present yield records are amplified and the general investigation extended.

Discussion

The demonstration of the presence of distinctive types of sieve-tubes in the main stem and branch system of Hevea (Plate 8), combined with an appropriately co-ordinated latex-vessel system (Plates 9 and 10), provides evidence which, in the writer's opinion, can only be interpreted in the light of the hypothesis developed in the introduction to this paper. The assumption that the different yield potentialities of individual trees of Hevea may be closely correlated with definite differences in anatomical constitution is strongly supported.

It appears, however, that the relationship is not perfect; although it is sufficiently well-defined to permit of the immediate recognition of low-yielding types it is of doubtful value in differentiating between trees of a high-yielding category. This is illustrated by the results summarised in Table 1 which show that large-diameter sieve-tubes may be encountered in trees with a rather wide range of yield. At the same time, attention has been drawn to the fact that the indicated yields, since they are based on the records of early tapping tests, may not be an entirely reliable index of yield capacity and may be subject to considerable modification as the trees increase in age.

Evidence of this is forthcoming from the study of the yield history of some of the well-known proved clones of Hevea. Cer-

tain clones, which might quite easily have been discarded on the results of their earliest tests, have reached in subsequent years a very high level of yield. For this reason several years of careful recording are necessary before a true evaluation can be made.

Thus, for example, for the apparently aberrant trees shown in Table 1, Groups 1 and 2, and Grades 3 and 4, a further increase in yield would transfer them to a position in accord with the expected gradient indicated by their anatomical constitution. It is tempting to suggest that young trees which possess the anatomical characters now known to be closely associated with high yield, may show a marked increase in productive capacity with increase in age, whilst those trees whose anatomical constitution is of the type associated with low yield are unlikely to improve materially. It is only by extended observation and careful recording of individual tree yields that the evidence necessary to confirm or refute this suggestion will be forthcoming.

The demonstration of marked differences in size and distribution of latex vessels in the bast of different trees is of particular interest in relation to the numerous investigations in which the aim has been to establish a correlation between yield and number of latex-vessel rings. Although in the present investigation only a proportion of the trees available has been examined in detail, it cannot be doubted that the number of additional latex-vessel rings required in a typical low-yielder to compensate for the superior size and development of the latex-vessel complement of a high-yielder such as No. 512 (Plate 6) is unlikely to be found. Sufficient evidence has been presented to show that trees of the same type as No. 512 have a very definite superiority in yield capacity which may be quite independent of the relative number of latex vessel rows. (Figure 1A and B).

The results so far achieved are of value in directing attention to the necessity of extending the range and scope of the investigation. The early work on the genetics of Hevea indicates a high degree of self-sterility suggesting a large hybrid population and it is therefore particularly desirable to study under carefully-controlled conditions the mode of inheritance of the two contrasted type of sieve-tubes in first generation crosses. This work should be carried out in conjunction with a study of the chromosome complex in Hevea variations which may have a profound influence on the interpretation of the difficulties so far encountered. Evidence obtained from these investigations would probably extend and confirm the value of the facts so far established in their bearing upon the important problem of yield prediction.

Figure 1

A

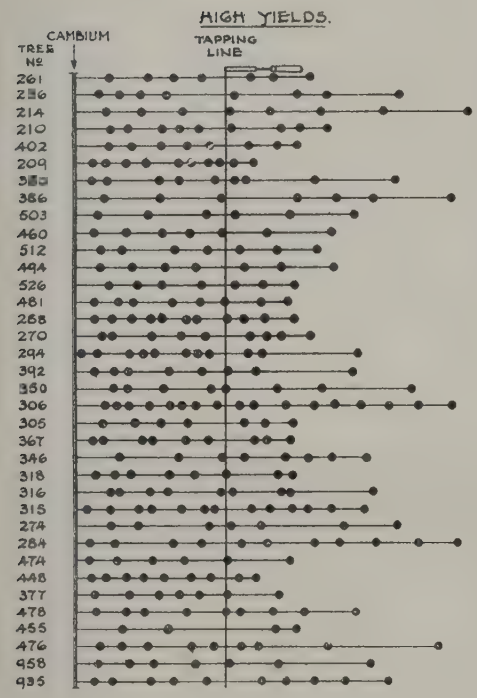


Figure 1

B

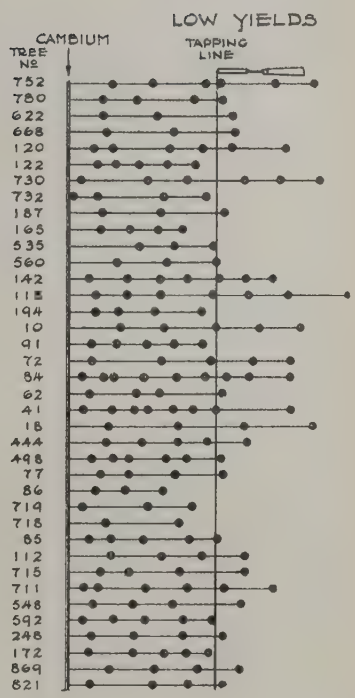


Diagram illustrating the distribution of latex-vessel rings in the bark of 4-years-old trees showing the total number of rings and the number opened when the bark is tapped to within 1 mm. of the cambium—

A. Condition in bark of high-yielding trees

B. Condition in bark of low-yielding trees (× 35)

(Each dot indicates the position of a latex-vessel ring)

Summary

1. An investigation of the anatomical structure of the sieve-tube latex-vessel complex in the bast of *Hevea brasiliensis* is described.

2. Two extreme types of sieve-tube have been shown to occur.

3. Sieve-tubes of small diameter are associated with narrow-bore latex vessels in trees with low latex-yielding capacity. Sieve-tubes of large diameter are associated with latex vessels of large bore, and all trees of high-yielding capacity which have been studied in the present investigation have been found to possess sieve-tubes and latex vessels of this type.

4. The presence of a constant type of sieve-tube in all parts of the tree (Plate 8) and the demonstration of the advanced development of the sieve-tubes in the bark of one-year-old stems permits of immediate qualitative analysis of a mixed population of young seedlings and suggests a means whereby low-yielding individuals may be eliminated at a very early stage.

Acknowledgment

The writer is indebted to his colleagues in the Botanical Division for the provision of the carefully-recorded material used in the course of this investigation. The valuable assistance of Mr. M. I. Nair in the collection of material and collation of yield records is recorded with appreciation. For assistance in the preparation of this paper for publication the writer is indebted to Mr. C. E. T. Mann.

Literature Cited

(1) Summers F. *The Improvement of Yield in Hevea Brasiliensis*

Plates

1. A. Transverse section of a 1-year-old stem of a budding of a high-yielding clone showing the sieve-tubes of large bore characteristic of this clone (× 180)

   B. Transverse section of the bark of a 6-years-old tree showing

   (1) Cambium zone
   (2) Sieve-tubes and latex vessels
   (3) Stone-cell region—cortex (× 30)

2. A. Radial longitudinal section through the inner bark (bast) showing two sieve-tubes with sieve-plates in surface view (× 550)
   B. Isolated sieve-tube showing sieve-plate in profile (× 250)
   C. Tangential longitudinal section of inner bark showing
      (1) Medullary rays in transverse section
      (2) Sieve-tubes
      (3) Sieve-plates in profile (× 120)
3. Transverse sections of the bark of 6-years-old seedlings. Low-yielding trees (× 100)
4. Transverse sections of the bark of buddings of high yielding clones (× 100)
   (Compare sizes of sieve-tubes in Plates 3 and 4)
5. Transverse sections of the bark of 6-years-old seedlings. Low-yielding trees (× 100)
6. Transverse sections of the bark of high-yielding seedlings 6 years of age (× 100)
   (Compare sizes of sieve-tubes in Plates 5 and 6)
7. Transverse sections of the bark of budded trees of established high-yielding clones (× 100)
8. Transverse sections showing sieve-tube development in bark of different ages from seedling trees.
   A. Bark of high-yielding tree (Tree No. 512. Block 2)
   B. Bark of low-yielding tree (Tree No. 142. Block 2)
      (i) Shoot a few months old
      (ii) Bark one year old
      (iii) Bark two years old
      (iv) Bark three years old (All × 100)
9. Transverse section of bast of 6-years-old seedling of low yield capacity showing size and distribution of the latex vessels (× 200)
10. Transverse section of bast of 6-years-old seedling of high yield capacity showing size and distribution of latex vessels (× 200)
    (The latex vessels are shown coloured in plates 9 and 10).

Text Figure

Figure 1. Diagram illustrating the distribution of latex-vessel rings in the bark of 4-years-old trees showing the total number of rings and the number opened when the bark is tapped to within 1 mm. of the cambium. (Each 'dot' indicates the position of a latex-vessel ring).

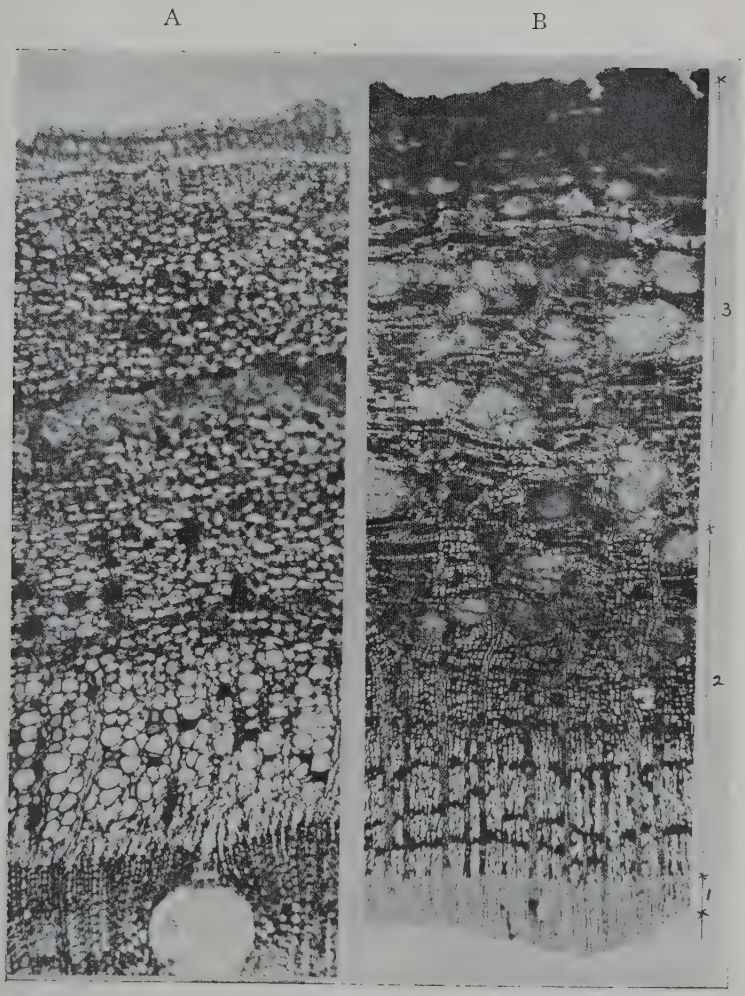
The diagrams have been constructed from camera-lucida drawings made at a magnification of × 35.

A. Condition in bark of high-yielding trees.

B. Condition in bark of low-yielding trees.

Kuala Lumpur,
17th June, 1935.

PLATE 1



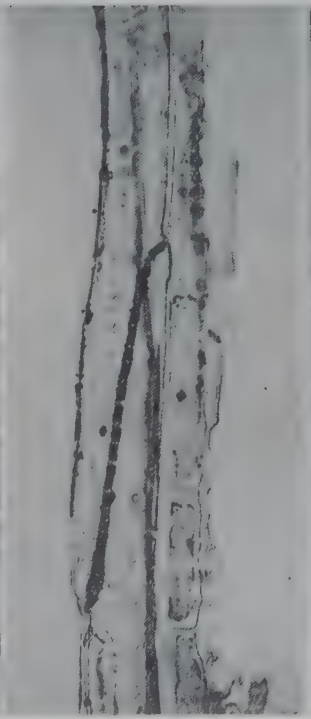
A. Transverse section of a 1-year-old stem of a budding of a high-yielding clone showing the sieve-tubes of large bore characteristic of this clone. (× 180)

B. Transverse section of the bark of a 6-years-old tree showing (1) cambium zone, (2) sieve-tubes and latex vessels, (3) stone-cell region—cortex. (× 30)

A

Radial longitudinal section through the inner bark (bast) showing two sieve-tubes with sieve-plates in surface view. (× 550).

B



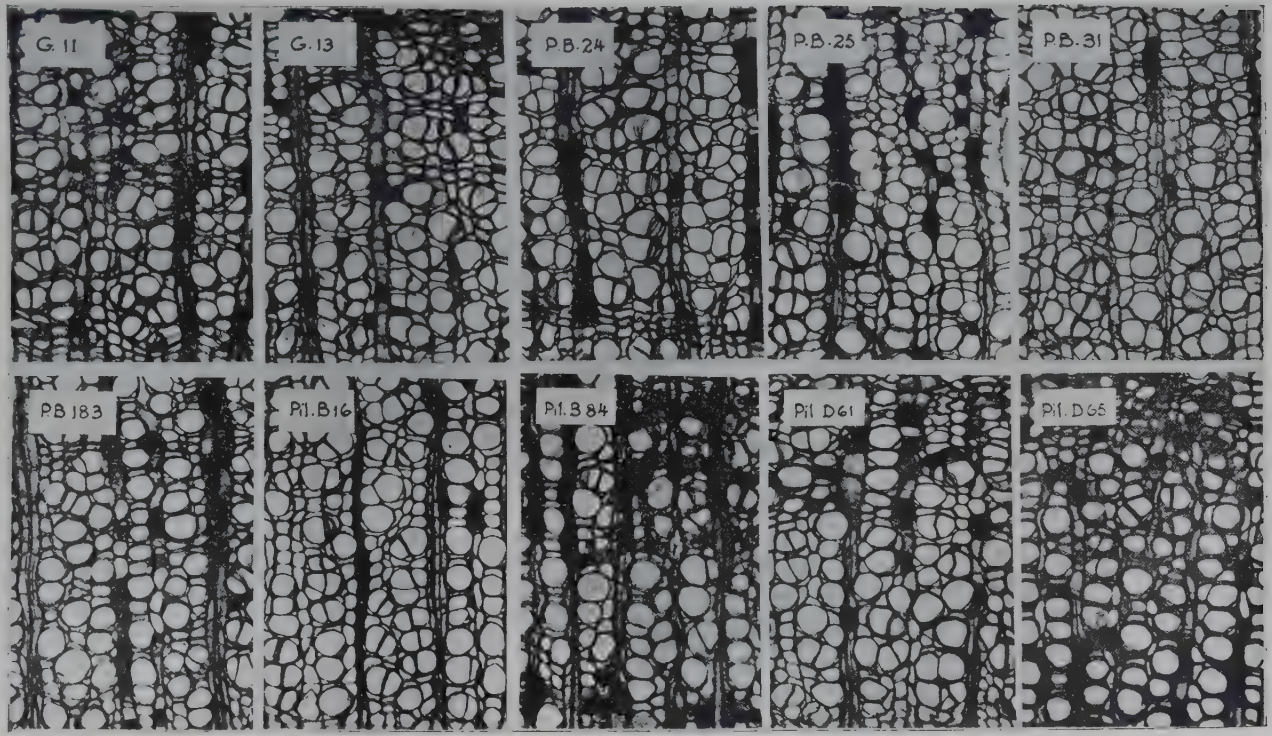
Isolated sieve-tube showing sieve-plate in profile. (× 250).

C

Tangential longitudinal section of inner bark showing (1) medullary rays in transverse section, (2) sieve-tubes, (3) sieve-plates in profile. (× 120).

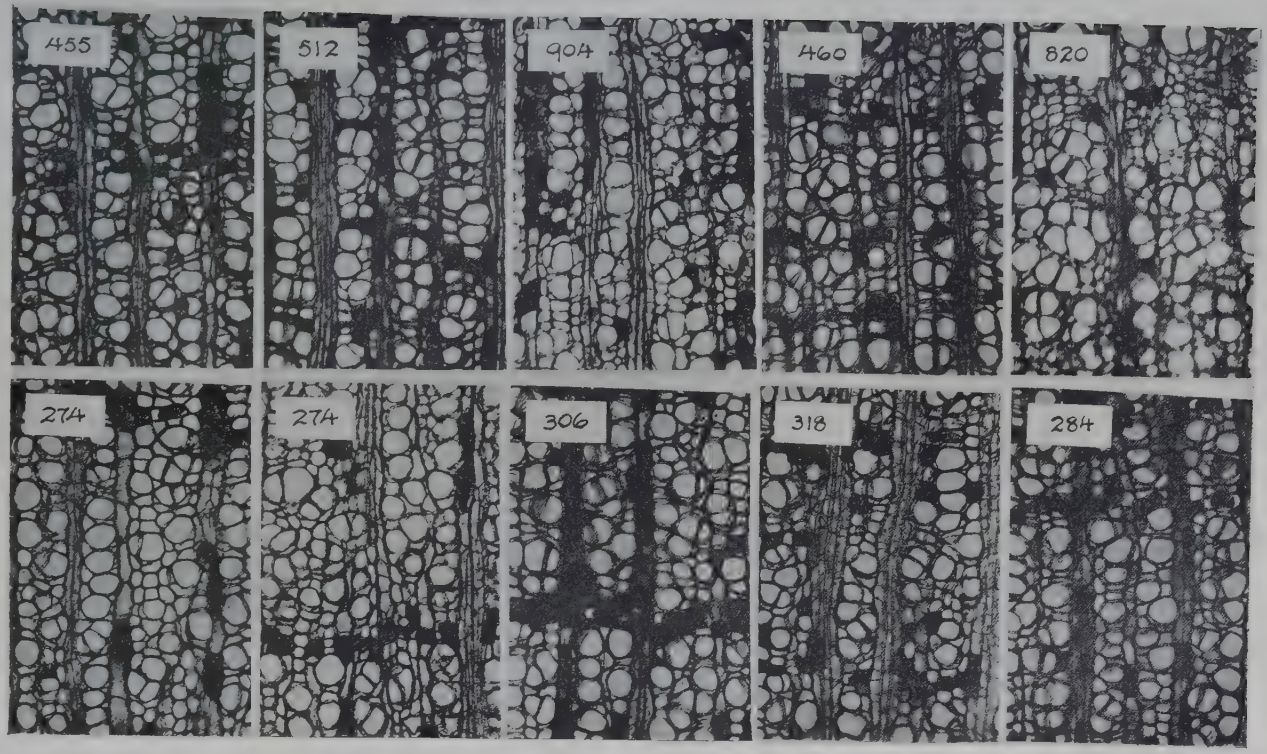
PLATE 2

Transverse sections of the bark of 6-years-old seedlings; low-yielding trees. (× 100)



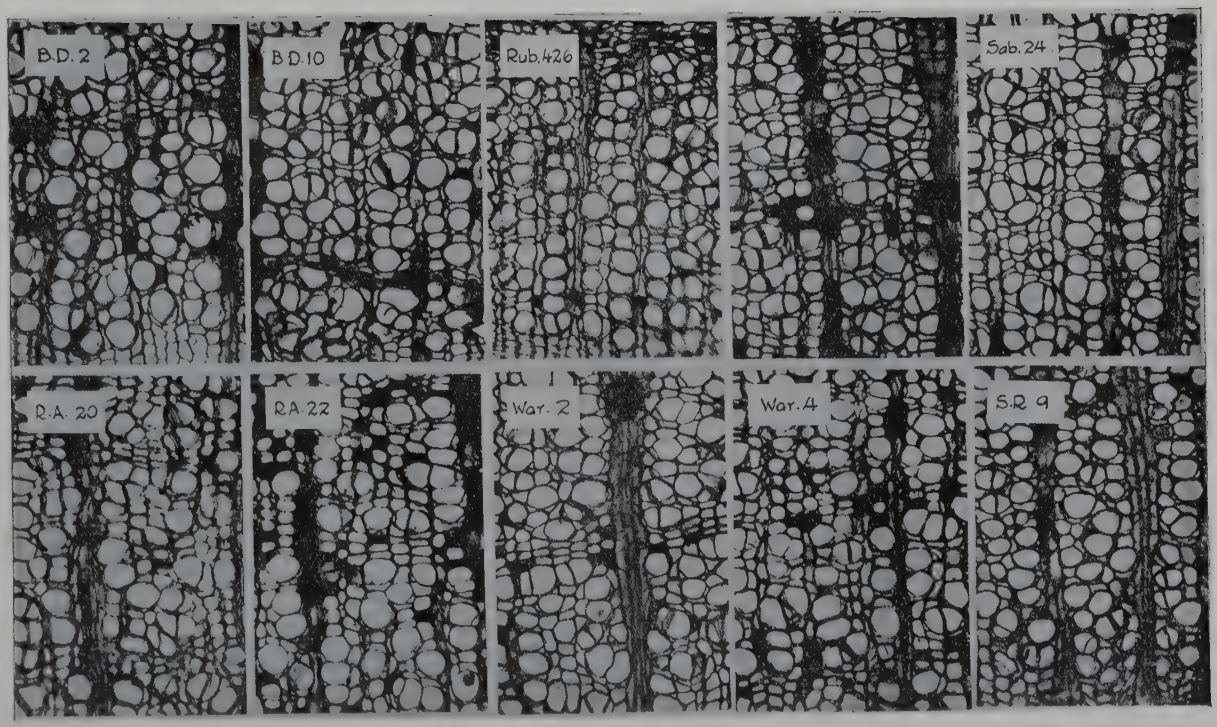
Transverse sections of the bark of buddings of high-yielding clones. (× 100)

(Compare the sizes of the sieve-tubes in Plates 3 and 4)



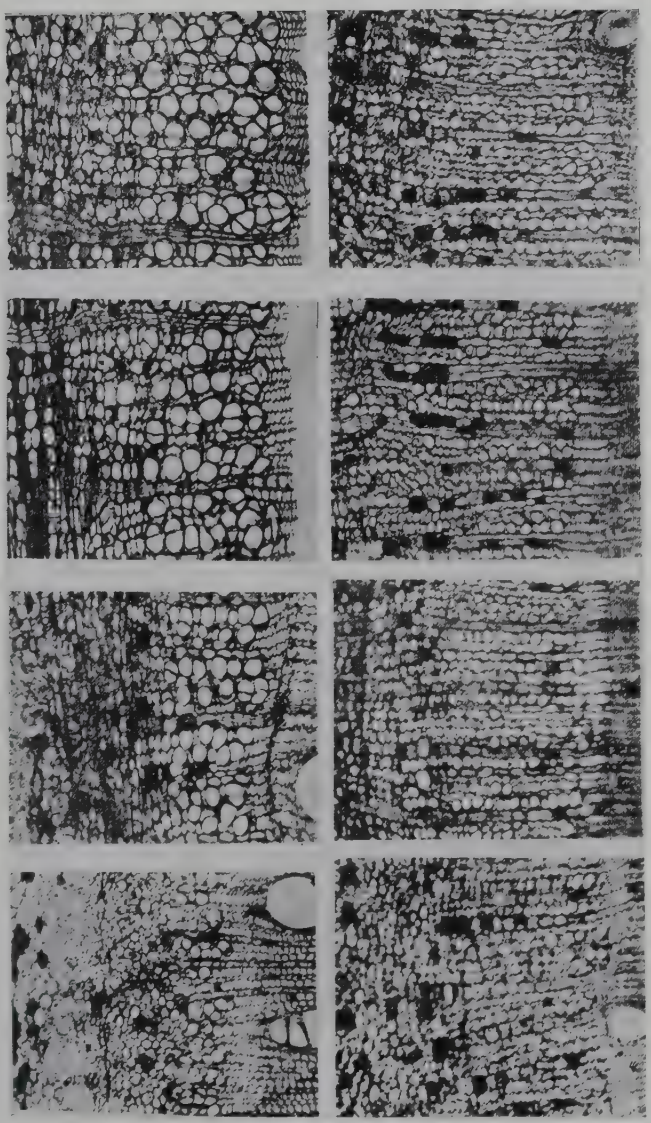
Transverse sections of the bark of 6-years-old high-yielding seedlings. (× 100)

(Compare the sizes of the sieve-tubes in Plates 5 and 6)



Transverse sections of the bark of budded trees of established high-yielding clones. (× 100)

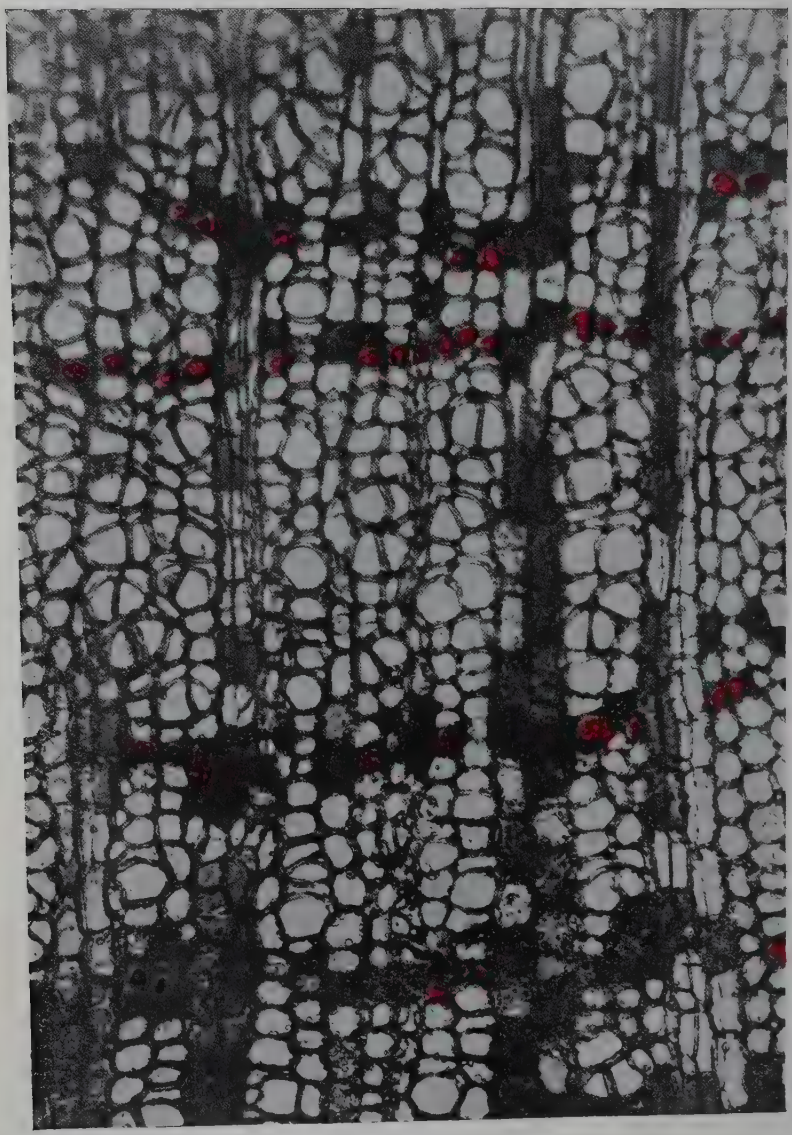
PLATE 8



Transverse sections showing sieve-tube development in bark of different ages from seedling trees—

A. Bark of high-yielding tree (Tree no. 512 in Block 2 of R.R.I. Experiment Station).

B. Bark of low-yielding tree (Tree no. 142 in Block 2 of R.R.I. Experiment Station). (× 100)



Transverse section of bast of 6-years-old seedling of low yielding capacity showing size and distribution of the latex vessels. (× 200)

(The latex vessels are shown coloured)

Transverse section of bast of 6-years-old seedling of high yielding capacity showing size and distribution of the latex vessels. (× 200)

(The latex vessels are shown coloured)

RECENT PROGRESS IN THE SELECTION OF PLANTING MATERIAL OF HEVEA*

BY

C. E. T. Mann

During the past two or three years attention has been focussed more and more upon the possible value of "clonal" seedlings (*i.e.*, seedlings grown from authentic seed picked from budded trees of the well-known proved clones) as planting material which it is hoped may prove equal in ultimate productive capacity to buddings of the best proved clones. Early tests have shown that the trees of certain seedling families, developed as the result of carefully controlled breeding work, have actually given yields which approach closely, and may even in certain cases exceed the yields obtained from budded trees of some of the best-known clones at comparable age. So encouraging have been the results of these early investigations in breeding that an impression is rapidly gaining ground that the time has already arrived to abandon vegetative propagation and the planting of budded trees of well-proved clones in favour of planting with seedling trees derived from so-called clonal seed.

The more important evidence in support of or opposed to this view is presented and discussed in this paper.

The earliest work on the study of the inheritance of high-yielding qualities in rubber by means of carefully controlled breeding experiments is that of Heusser at the A.V.R.O.S. Experiment Station in Sumatra.

After the careful recording of the yield of individual trees over several years, a collection of valuable high-yielding trees was built up. This collection formed the basic material for two important series of investigations having as their common aim the improvement of yield in Hevea and the provision of planting material of superior quality for general commercial use.

From this point, investigation pursued the two main lines commonly adopted in the improvement of a race of plants; firstly, by vegetative propagation which led to the establishment of superior clones, and secondly, by means of controlled crosses between carefully selected parent trees in an endeavour to produce high-yielding races or "strains."

* This paper is the full text of a lecture given at a meeting of the Rantau—Port Dickson Branch of the Incorporated Society of Planters on June 28th, 1935.

The progress of the work on the development of high-yielding clones is familiar to all, but the results of the work on breeding are less well known, since the rate of progress is necessarily much less rapid and spectacular.

In 1918—1919 Heusser made clones from his selected mother trees, and in 1920 a large programme of hand-pollinations was carried out between parent trees chosen from his basic collection. This work with Hevea is difficult, and often discouraging, since the percentage of successful pollinations obtained, which yield viable seeds, is very small.

The fertility of different parent trees varies greatly. In certain combinations the number of fruits set and ripened to maturity may be as high as 40 per cent of the total number of pollinations made, while in others less than one per cent success may be obtained. An average result of five ripe pods from 100 flowers pollinated may be considered normal for this work. The reason why progress in this field is relatively slow will be readily appreciated.

As a result of a full season's work, 1450 seedlings were obtained, derived from 17 parents in 30 different combinations. These were planted as stumps between October, 1921, and January, 1922, at a density of 85 trees per acre.

Tapping was commenced on all trees which showed a girth of 16 inches at a height of 40 inches from the ground (*i.e.* about 19 inches at 20 inches) when the trees were just four years old from the date of planting as 'stumps'. As other trees reached the necessary standard they were brought into tapping and by the end of the first tapping year, 85 per cent of the trees were being regularly tapped. The system used was in all essentials equivalent to the normal commercial system of tapping in general use on seedling trees in Sumatra at that time. During the first two years, tapping was on a half-circumference left-to-right spiral cut at a slope of 30 degrees on a panel opened at a height of 20 inches and tapped to ground level. Tapping was daily in alternate months and bark consumption was 10 inches per year. The second panel was opened to the left of the first panel, at a height of 30 inches on one-third of the circumference and tapped to ground level in three years. The third panel was opened to the left of the second, also on one-third of the circumference. A part of this cut entered the renewed bark of the first panel during the seventh year of tapping. On each tapping day the latex was coagulated in the cup and the coagulated samples were collected separately. The total weight of dry rubber per tree per tapping was obtained monthly from the total weight of the samples for the month, after crêpeing and drying. On account of the extra work

involved in coagulating and collecting samples the tasks consisted of 150 to 200 trees. As the actual tapping operation would take no longer than in ordinary practice, the advantage of early tapping on individual tree yields should not be overlooked. Planted in the same experimental area as the crosses was a small block of ordinary, unselected seedlings and these were tapped and recorded for comparison with the 'pedigree' material.

In Table I a summary of the yield records of the pedigree material as a whole is given and, for comparison, the corresponding records for the ordinary seedlings. The outstanding superiority of the seedlings derived from selected high-yielding mother trees is at once apparent. Had the stand per acre of the pedigree material been as high as that of the unselected seedlings the results would have been still more impressive.

TABLE I

Records of the Yields of legitimate Seedlings, obtained by Hand-Pollination between selected high-yielding Parents, and comparative Records of the Yields of unselected Seedlings

Description	Tapping year Age in years	1st year 4-5	2nd year 5-6	3rd year 6-7	4th year 7-8	5th year 8-9	6th year 9-10
CROSSES	Yield per acre in lb.	126	391	461	639	768	759
	Yield per tree in lb.	2.04	5.9	6.7	9.4	11.7	11.3
	Trees per acre tapped	61	66	69	68	65	67
CONTROLS	Yield per acre in lb.	68	211	226	354	500	401
	Yield per tree in lb.	1.05	3.0	2.7	4.2	5.9	4.7
	Trees per acre tapped	65	70	85	85	85	85

In comparing the aggregate yields of crosses and controls the following points should be borne in mind. All the crosses obtained were planted and, except for losses due to inherent weakness of the seedlings and losses from disease and mechanical damage, there had been no selection; all trees were tapped and their yields recorded as they reached the required standard of development. The relatively small increase in yield in the third tapping year and the fall in yield in the sixth tapping year were due to changes in tapping panels and reduction in the length of the tapping cut.

It should also be mentioned that the actual hand-pollinations were made before the buddings from the parent trees had been tested. It will be interesting to see later whether the selected trees which proved the best clone parents were also the best parents of seedling families.

As the system of individual tree recording has been maintained continuously it is possible to examine in detail the relative values of the different families of seedlings and the different family groups, *i.e.* the groups of seedlings having one common parent.

For the full details of this comparison the original publications should be consulted,* but the more important points can be illustrated by reference to selected examples.

In Table II the yield records of the trees of three seedling families are given.

TABLE II

Records of the Yields, in lb. dry Rubber per Tree per Year, of legitimate Seedlings of three Families and one Family Group

Cross or Group	No. of Trees	Tapping year 1st Age:-4-5	2nd 5-6	3rd 6-7	4th 7-8	5th 8-9	6th 9-10
49 × 26	95	3.4	7.4	7.3	8.0	9.1	10.7
36 × 35	12	2.7	6.2	6.0	7.8	10.1	11.1
157 × 164	67	3.6	9.9	12.2	16.9	21.0	16.8
157 Family group	143	3.5	9.5	10.0	13.8	17.7	14.6

* Heusser *Archief v.d. Rubber Cultuur* **5** (1921) 11.
13 (1929) 531.
14 (1930) 394.
16 (1932) 129.
16 (1932) 378.

It will be seen that the cross 157 × 164 is a great deal more valuable than either of the crosses 49 × 26 or 36 × 35. Both the latter families approximate in yield value to the average of the whole collection whilst the yields of seedlings of 157 × 164 are very much above the average. It is particularly interesting to notice that in the crosses 49 × 26 and 36 × 35 one or both of the parents has proved to be a valuable clone parent. Buddings from Clones 35, 36 and 49 have been tapped since 1923 and all three have been found to be valuable high-yielding clones. On the other hand, the buddings derived from the parent trees 157 and 164 have not given high yields and the clones were discarded at an early stage of testing.

In the 30 families of seedlings represented in Heusser's collection, some of the parents have been used in different combinations in several families. By computing the average yields of all trees in those families which have one parent in common it is possible to obtain a clear idea of the relative values of the various parents. It is found as a result of this examination that all families having 157 as a parent have given very high average yields. The mean yield of all descendants of 157, *i.e.* the family group, are shown in Table II. The detailed records of the five families in which the selected parent 157 has been used, are given in Table III. In parent 157 Heusser has made a very valuable discovery for it appears that this parent possesses to a very marked degree the power to transmit its high-yielding properties to its seedling offspring.

TABLE III

Records of Yields of the Crosses of the Family Group from Parent 157

Cross M F	No. of Trees 6th tapping year	Yield per tapping in gm. Tapping year					
		1	2	3	4	5	6
157 × 164	67	10.19	28.19	34.65	48.08	59.75	47.84
157 × 166	43	9.92	26.47	25.47	36.84	46.05	44.56
157 × 161	8	7.84	23.92	26.46	44.40	60.06	48.05
157 × 151	3	12.73	27.70	30.43	33.83	47.12	30.35
142 × 157	22	9.20	28.28	25.40	32.64	38.25	36.54
Average of all trees	143	9.98	26.91	28.48	39.16	50.25	41.47
Pounds per tree per year 160 tappings	...	3.5	9.5	10.0	13.8	17.7	14.6

Although 157 has proved to be the best parent in this first careful investigation the value of other very promising parent trees should also be mentioned. For example, mother tree 33 has given on the whole good high-yielding seedling families and, in addition, has given very high-yielding buddings. This parent, therefore, possesses the double virtue of being able to transmit its high-yielding qualities to both its vegetative and seedling offspring. Seedlings grown from the seed produced by buddings of Clone 33 have also proved to be very promising and further mention of these will be made later.

So much for the yielding capacity of the crosses; the secondary characters, vigour, bark quality, resistance to disease and mechanical damage, have all been carefully studied. It is found that all these characters may be transmitted from the parents to the seedlings. Thus, in the families derived from parent 36 the weak branching characters of the buddings of the clone developed from this parent are shown to a considerable extent in its seedlings. Parent 33 is a small tree of rather weak growth and its buddings are also weak. It was chiefly on this account that the clone was removed from the list of those recommended for planting and it is interesting to note that growth of the seedlings derived from 33 is generally below average vigour. Clone 164 is very susceptible to brown bast and this tendency is most marked in the families derived from it. For example in the cross 157 × 164 traces of brown bast have appeared in 31 per cent of the trees; in the family 164 × 161, 39 per cent of the trees have been affected.

In addition to the seedlings obtained by careful hand-pollination between selected parents, seedlings obtained from budded trees of good clones planted in small isolated seed gardens and allowed to seed naturally have also been tested over five complete tapping years. The average yield figures for these seedlings as a whole are mentioned here since these indicate the level of yield which may be expected in practice from seed obtained from isolated seed gardens planted with budded trees of proved high-yielding clones. The proved clones from which the majority of the seedlings were derived are the A.V.R.O.S. Clones 33, 36, 49, 50 and 80. It is possible that, had the value of the clones been greater, the yields of the seedling offspring might also have been higher but the results obtained with such clones as 157, 161 and 164 do not support this view. In actual practice the average yield of the seedlings derived from these selected clones in isolated gardens was about equal to the average yield of the total collection of the crosses described above.

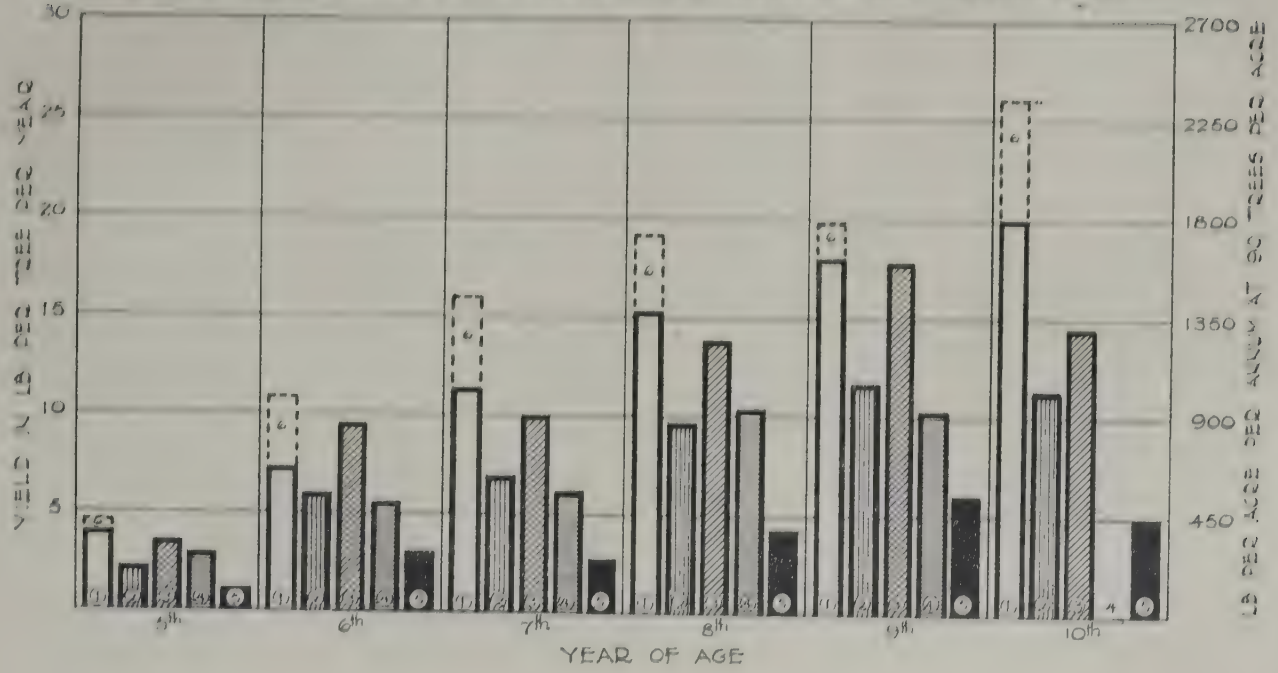

COMPARISON BETWEEN YIELDS OF BUDDINGS OF PROVED CLONES, SEEDLINGS FROM CLONAL SEED AND UNSELECTED SEEDLINGS.
YIELD IN LB PER TREE PER YEAR
LB PER ACRE PER ANNUM AT 90 TREES PER ACRE
30
25
20
15
10
5
2700
2250
1800
1350
900
450
5th
6th
7th
8th
9th
10th
YEAR OF AGE

FIGURE 1

To facilitate comparison, the yield records of the seedling trees of different origin, which have been described in detail so far, are represented graphically (Figure 1). The mean yields per tree per annum are shown by vertical columns. Six columns are drawn for each year of age; columns 1 and 6 are superimposed. Column 1 indicates the average annual yield per tree obtained from buddings of the 20 best clones which have been recommended for commercial planting. Column 6 shows the yield per tree of buddings of one of the highest-yielding clones yet developed and indicates the level which may be reached by one of the best clones in comparison with the best seedling family. Column 2 shows the mean annual yield per tree of Heusser's total collection of seedling crosses. Column 3 indicates for comparison with 2, the records for seedlings derived from parent 157. Column 4 shows the mean yield of the seedlings from isolated seed gardens planted with good proved clones and column 5 the yields of ordinary unselected seedlings, tapped for comparison with the crosses as a control.

The main conclusion to be drawn from the results of this work is that seedlings derived from high-yielding parents will give very much higher yields that unselected seedlings. There can be no question that the pioneer studies of Heusser have demonstrated conclusively the value of careful breeding work with Hevea in the search for seedling families which may be capable of high average yields comparable with those obtained from budded trees of the best clones. The success of this first investigation exceeded expectation but at the same time it has brought to light new problems. One of the most important features of the work is the discovery that the parents of the highest-yielding clones do not necessarily give seedling offspring of the same high-yielding category as their parents or as buddings made from them. It is obviously necessary, therefore, to use the term "Clonal seed" with caution, for the term may be applied quite correctly to material which is not much more valuable than ordinary seedlings derived from a common seedling plantation or to seedlings comparable with the families derived from parent 157.

It is unfortunate that for many of the high-yielding clones which have been used in the large commercial areas planted with buddings we have very little information regarding the value of the seedlings derived from them. As regards the A.V.R.O.S. clones, many of the selected mother trees which have since been shown to give very valuable buddings were not readily accessible when Heusser's pollination work was in progress and this, no doubt, accounts for their omission from the group of parents used. In view of the results obtained with the few well-known clones which were employed it would clearly be extremely dangerous to assume

that any high-yielding clone will give seedling offspring equal in value to the 157 family group. Since seedlings of this family group are the only ones which have been shown to equal the yields of buddings of the best proved clones it is clearly necessary to investigate for each individual clone the value of its seedling offspring before contemplating their use in place of buddings.

Since the early work of Heusser, other investigators have carried out breeding work on Hevea on somewhat similar lines. In 1928 Morris* commenced breeding investigations at the Rubber Research Institute using as his parent material budded trees of a number of young clones established on Pilmoor Estate, Selangor. The budded trees employed as parents have been regularly tapped and recorded since January 1928, so that their yield performance and general characters are thoroughly well known. The first crosses made were planted on the Institute Experiment Station between January and May 1929 at a density of 108 trees per acre. After test tapping in January and July 1934 the trees were brought into regular commercial tapping in January 1935. Interplanted with the legitimate crosses are groups of illegitimate seedlings from the several parents, seedlings from high-yielding mother trees and seedlings from "selected seed" taken from high-yielding areas on estates. From the yield records available so far, the average yield per tree in pounds of dry rubber per annum has been calculated for the 6th year of age i.e. from the 5th to 6th year from the date of planting. The yields estimated in this way are not, of course, strictly accurate but, since the first month of tapping and two months of wintering are included in the estimates the yield index figures obtained are not likely to exceed the actual yields of which the trees are capable.

All trees having a girth of 20 inches at 20 inches from ground level have been opened for tapping with a left-to-right spiral cut over half the circumference at a slope of 22 degrees. Bark consumption is $\frac{3}{4}$ inch per month and tapping is alternate-daily. Good Tamil tappers are employed in tasks of 275 trees and the yields of individual trees are recorded every month by means of cup coagulations.

Table IV shows the comparative yields of all seedlings, arranged in family groups according to parentage, and, for comparison with the seedlings, the yields of the buddings from which they have been derived are also given. The difficulties of hand-pollination work have already been mentioned and the particular difficulties encountered in the breeding of the seedlings in the

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* *Journal R.R.I.M.*, **1** (1928) 41 & 121.
Annual Reports, R.R.I.M., 1928—1934.

TABLE IV

Comparative Yield Records of legitimate Seedling Crosses, illegitimate 'clonal' Seedlings and Buddings

Family Group	Yield index in lb. per tree in 6th year of Age							
	A. 44	B. 16	D. 61	B. 58	A. 8	B. 84	B. 95	Control Seedlings
Crosses	9.0	4.9	5.6	5.2	5.9	11.3	7.0	
Illegitimate seedlings (Clonal seed)	8.1	1.2	4.2	4.1	3.9	4.2	2.1	2.0
Buddings: 6th year	6.6	8.7	6.3	7.2	2.6	7.1	1.7	
10th year	9.5	18.6	10.9	12.9	—	18.5	6.8	
Crosses excluding the progeny of A 44.	—	3.3	2.7	3.2	4.1	—	—	

present investigation have been described by Morris in an early publication. However, in Clone A. 44 a fertile parent was found and the largest number of successful crosses was obtained with this clone as a parent. Crosses were obtained between A. 44 and each of the other selected clones. The crosses shown under B. 84 and B. 95 are both crosses with A. 44 as a parent and only one family was obtained with each. The records show that the outstanding family group is derived from parent A. 44. In all combinations high-yielding seedlings have been obtained when A. 44 has been one of the parents. Where high yields are shown in other family groups the presence of A.44 as one of the parents of a large proportion of the individuals is mainly responsible for the high average figure. It looks as though we have found in A. 44 a parent of the same type as Heusser's 157. The inclusion of illegitimate seedlings in the collection enables us to carry our investigation a stage further. The very high production of the illegitimate seedlings of A. 44 strengthens the view that this clone possesses to a very marked degree the power to transmit its high yielding qualities to its seedlings, despite the possible influence of an inferior mother or father.

It is rather a striking fact that in no other family group, omitting for the moment the single crosses B. 84 × A. 44 and B. 95 × A. 44, does the mean yield of the crosses equal the yield

of the buddings at comparable age. In every instance, except for A. 44, the average yields of the illegitimate seedlings are considerably below the average yields of the buddings. For A. 44 the yields of crosses and illegitimate seedlings are considerably higher than the yields of the buddings at the same age. The value of these comparisons must not, however, be given too much weight at present. The records of yield of the buddings were taken in 1930 in the original experimental area on Pilmoor Estate, so that allowance must also be made for possible differences in environment and soil fertility (although some of our critics would not allow that the trees on the Experiment Station are likely to be favoured much on this score).

It would be dangerous to draw hasty conclusions from these early results, as the history of the buddings of Clone A.44 is somewhat disappointing. During the earliest tapping tests this clone was by far the best yielder, but in the second tapping year it showed a much smaller increase in yield than the other clones. By the end of the seventh tapping year, instead of taking first place A.44 was sixth with an increase in yield from the third to the seventh tapping year of only 2.9 pounds per tree per annum, whilst in clone B.84 the yield per tree showed an increase from 7.1 to 18.5 pounds during the same period. It is possible that seedlings derived from A.44 may exhibit similar characteristics of precocity and poor rate of increase in production.

Throughout the experimental area ordinary seedlings grown from mother-tree seed from two selected high-yielding trees, and from good quality estate seed, have been grown and tapped with the crosses and illegitimate clonal seedlings. An average yield of two pounds per tree per annum is indicated. The average yield of the illegitimate clonal seedlings is about double this figure and the average yield of all crosses is about three times as large.

It is not intended to deal fully with the secondary characters of the various families as the trees are too young for observations of these characters to have much value. There are, however, one or two features of interest. The buddings of A.44 develop somewhat corrugated trunks and irregular bumpy bark; the same features are noticeable in many of the seedlings but generally at such a level that they do not affect the tapping surface. Clone B.95, a mediocre clone as regards yield, was chosen as a mother parent on account of its excellent secondary characters. When crossed with A.44 the seedling offspring appear to have many of the desirable characters of B.95 combined to a satisfactory degree with the high yield qualities of A.44. The best clone in the collection, B.84, has given excellent crosses with A.44 and this family contains two of the highest yielders in the whole area.

The results to date are in striking agreement with those obtained by Heusser and strongly support the conclusions reached from the earlier work.

In May this year further evidence in confirmation of the value of breeding work with Hevea was published in an important circular* issued by the Prang Besar Rubber Estate, Ltd. Under the heading "Selected Seed" a concise account of the investigations conducted by Chittenden is given, together with results obtained in the first complete year of tapping on seedlings derived from some of the well-known Prang Besar clones. Chittenden's work has been conducted on much the same lines as the work at the Institute. His basic material consisted of a collection of promising young clones and selected clones have been used as parents in an extensive programme of hand-pollination work.

All seedlings obtained have been planted and, as soon as the trees have attained a girth of 19 inches at 20 inches from the collar, they have been brought into tapping on a normal alternate-day system of tapping on a half-circumference with a left-to-right spiral cut. The crosses made in 1928 and 1929 have been tapped since January 1934. To judge from the standard of girth development set for tapping the growth of the 1929 crosses has been exceptionally good, considerably better than the growth of the crosses made by Heusser and Morris. Possibly environmental factors are responsible for this or it may be that particularly vigorous parents have been selected.

From the data given in the published tables it is shown that the average yield per tree of all crosses made in 1928 reaches the high level of 6.8 lb. per tree per annum. The yields of the crosses made in 1929 are even more striking, for although the trees are a full year younger, the average yield per tree per annum is 6.4 lb.

A list of the parent clones used is given but as no information is given as to the manner in which parents have been crossed and the relative values of the seedlings in the different families it is not possible to examine these most promising results in more detail. In view of the discovery of such parents as A.V.R.O.S. 157 and A.44 in the previous investigations it would be extremely interesting to know whether similar outstanding parents have been discovered in the course of the present investigation.

A summary of the comparable results obtained to-date in the three series of investigations received so far is given in Table V.

* Prang Besar Rubber Estate, Ltd. Circular dated 30th April, 1935.

TABLE V

Summary of Results of early tapping Tests on Seedlings obtained by Hand-Pollinations between high-yielding Parents

Investigation	Description of Material	Yield in pounds per tree per annum	
		5th year of age	6th year of age
A.V.R.O.S.	All crosses	2.1	5.9
	Family 157	3.5	9.5
R.R.I.	All crosses	...	7.6
	Family A.44	...	9.0
Prang Besar	All crosses 1928	...	6.8
	All crosses 1929	6.4	...
Average yield of Buddings of 20 good Clones		...	7.1
„ „ of a first-class clone		...	12.0

The general conclusions to be drawn from the results of the work reviewed are that it is possible by means of carefully controlled crossing of selected high-yielding parents to raise families of seedlings which, without further selection or elimination of the poorer individuals, are capable of yields at least twice as great as the yields obtained from ordinary unselected seedlings. The best families produced so far are capable of an average production closely approaching that of buddings of a good proved clone, but the highest yield level attained by the best seedling family yet described does not reach that of the best proved clones.

The application of these results to practice presents considerable difficulty. It has been frequently stated that by planting buddings of high-yielding clones in isolation and allowing free crossing between these, then the mixed collection of seed obtained from such an area is likely to give results comparable with those obtained from the carefully-raised families which have been described here. It would be as well to examine this claim a little more closely.

The amount of crossing which may take place in an isolated seed garden will depend on the number of different parents present and the time at which the flowers of the different parents are in the condition when pollination will be effective. To take a simple example, buddings of two clones are planted in isolation. It is well known from a study of the oldest proved clones that flowering and fruit-setting for one of these clones may occur at a much earlier period in the season than for the other, with the result that there can be no guarantee that seed obtained from

the garden will be of anything like the same quality as the crosses which may have been obtained between the two clones by careful hand-pollination. Increasing the number of parents in an isolated garden is not necessarily an insurance against this disappointing possibility. The most valuable parent, suppose it happens to be of the 157 or A.44 type, may produce its flowers out of season and set very little seed, whilst other, less valuable, parents may seed freely. Variations in time of flowering of the different parents in different years may result in considerable variation in the value of the seedlings grown from successive seed crops.

These dangerous possibilities are purposely emphasized; some of them may be remote, but with the data from carefully-conducted experimental work available it seems desirable to focus further development along lines which are clearly indicated by the results.

For example, the fact that such clones as 157 and possibly A.44 when used as parents have given seedling offspring of the highest average quality yet obtained in every combination in which they have been studied, suggests that these parents should be the future seed-bearers, and that other very high-yielding parents should serve as pollinators only. In practice this would mean collecting seed only from the known superior parents. Although it is true that many of the seeds obtained from the less valuable parents might have been produced by cross-pollination with the selected parents and may therefore be equal in potential value, the general quality of the seed bearing different markings from those of the selected parents is likely to be diluted by the inclusion of a large proportion of seeds derived from less valuable crosses.

No mention has been made so far of another most important development arising out of the investigations which have been described. In the families of seedlings studied considerable variation in individual tree yield is found. Although the average yield of a family is high, some individuals are little better than the poorest members of an ordinary population of unselected seedlings and others give exceptionally high yields. For example, the family cross B.84 × A.44 contains one seedling which has yielded over 15 pounds dry rubber in six months and the tree is only just six years of age. From valuable individuals of this type new clones may be derived which show promise of being superior to any of the clones available at present. It is hoped that the work which is now being done in this direction will form the subject of a subsequent lecture.

Kuala Lumpur
6th July, 1935

SMOKE-HOUSE
FOR
CURING RUBBER ON SMALL-HOLDINGS

BY

B. J. Eaton

There has been a long-felt want for a cheap smoke-house for curing rubber on small-holdings. So far not much progress has been made in the endeavour to persuade small-holders to dry and smoke their sheet rubber on a co-operative basis, although in certain districts Malay small-holders' rubber is smoked in a smoke-house owned by one of themselves or by a Chinese, for which a charge of about $1 per picul (133-1/3lb.) is made.

Air-dried sheet

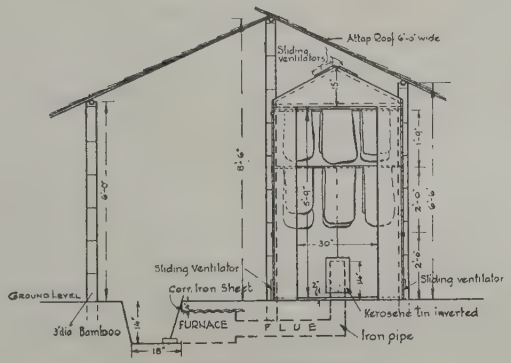
As a rule, the unsmoked or air-dried sheet prepared by the small-holder is by no means satisfactory, chiefly owing to the sheet being too thick, which renders drying at ordinary atmospheric temperature very slow, and secondly, to the fact that the coagulum receives very little washing during machining by hand-operated sheeting machines. Owing to this lack of washing, the sheet retains a higher proportion of serum, which is hygroscopic and renders the rubber more liable to develop moulds. Also, if the sheet is hung to dry too long in the open, tackiness is produced by the sun. This is particularly noticeable in a large proportion of the air-dried sheet exhibited in the District Agricultural Shows. Experiments carried out by the Rubber Research Institute show that such tacky rubber is inferior. If the air-dried sheet is only partially dried, the buyer or dealer will usually give even a lower price than is justifiable on the dry weight, since he has to make allowance for an unknown proportion of moisture and, either he or some subsequent buyer, has to dry the rubber before it can be used by the manufacturer. In some districts the small-holder prepares a very thick, lightly-machined coagulum which it is impossible to dry, until it has been crêped.

The loss to the small-holder by selling "wet" rubber has been recognised both in Malaya and Netherlands India.

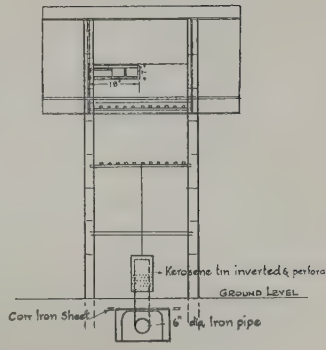
Smoked Sheet

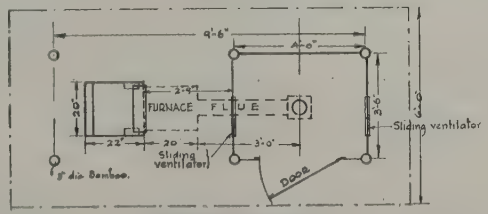
The smoking of sheet rubber is beneficial for several reasons; firstly, the heating at a temperature higher than that of the

SMALL-HOLDERS' SMOKE-HOUSE.



SIDE ELEVATION.





GROUND PLAN

Capacity: 60 sheets (Each sheet = 1 Catty) 60 Catties.
Smoking Period (Daytime smoking only) 4 days.
Walls & Roof – Gunny treated with Tapioca paste. (Boards can be used if preferred).
Corner Posts – Bamboos.
Broties – Light bamboos or Bertams.
Attap Roof on Poles to cover Smoke House and Furnace.

atmosphere accelerates the drying; secondly, the smoke acts as an antiseptic or fungicide and prevents or reduces the development of moulds in the rubber; thirdly, experiments carried out by the Rubber Research Institute show that such rubber is superior to both air-dried sheet and sheet dried by exposure to the sun.

Description of the Smoke-House

In describing the smoke-house, credit should be given to the small-holder in Perak who is responsible for the original construction and to the Rubber Instructors (Che Mohd. Shafii bin Ludin and Che Wan Chik bin Abdullah) who observed this smoke-house in operation and sent to the Institute a detailed description and drawing.

The original design has been improved at the Institute, chiefly in respect of ventilation and in the provision of a more satisfactory baffle to prevent sparks from the "furnace" coming in contact with the walls or with the rubber sheets, thus reducing the fire risk. These improvements are relatively inexpensive and easily carried out.

A great advantage of this smoke-house is that it can be constructed completely by the small-holder himself with materials which are readily obtainable in the *kampong* or the nearest village.

The principal materials required are attaps, gunny sacking, bamboos, a small quantity of meranti or other cheap wood, a kerosene tin, a short length of metal piping and a small piece of corrugated or sheet iron.

Capacity

The smoke-house described is capable of holding sixty sheets of rubber each weighing about one catty*, or 60 catties of dry rubber.

The drying and smoking period, if the sheet is sufficiently thin (not more than $\frac{1}{8}$ inch) is three to four days with no night smoking. If five days are allowed, as a maximum, a total quantity of 360 catties of sheet can therefore be smoked per month, which equals 4,320 catties per year, equivalent to the crop from about 13 acres, assuming a crop of 350 catties per acre. The smoke-house should therefore be suitable for several adjacent or neighbouring small-holders who may desire to co-operate.

If a larger smoke-house is constructed, the height and width should be maintained in about the same proportion, i.e. the height should be about one-and-a-half times to twice the width.

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*1 catty = 1⅓ lb.

Specification and Materials (See Plates 1—4)

The walls and roof of the smoke-house are of gunny sacking (hessian) which is nailed to four upright cylindrical poles or bamboos of about three inches diameter. The door consists of gunny sacking nailed to a framework of wood, the framework being about two inches wide and one inch thick. Two hinges are required for the door and a lock may be considered desirable but is not essential. The roof should be suitably sloped as shown in the line drawing (Plate 1) and the illustrations (Plates 2—4).

In order to protect the smoke-house from rain, an attap roof is constructed (see Plates 2 and 3). The ridge of this attap roof can be about two feet above the top of the smoke-house and should extend about 1½ feet beyond the side on which the door is situated and, if an outside furnace is used, as in the illustrations, should extend over the furnace as shown, in order to prevent rain from entering the furnace.

Since the hessian, where it is in contact with a damp soil, may rot, it may be desirable to place a sheet of tin or wood about six inches wide all round the walls at the bottom, so that the hessian does not touch the soil.

The gunny sacking used for the walls can be treated on the outside with a mixture of cattle manure and clay to render it more fire-proof and less porous. A mixture of sodium silicate and tapioca starch can also be used, but is probably not obtainable by most small-holders. (N.B. In the construction of the smoke house at the Rubber Research Institute, hessian treated with sodium silicate and tapioca starch was purchased from estates which use this material for packing rubber. Experiments are also being carried out to ascertain whether the treatment of the hessian with certain fire-proofing chemicals is desirable)

Furnace and Firing

On most inland small-holdings where the water table is low, the fire or furnace can be constructed below ground by digging a trench as shown in Plates 1 and 2, so that firing can be done outside.

A small length of pipe about three feet long bent at right angles to form a short chimney (about 14 inches long) inside the house, as shown in Plate 1, conveys the heat and smoke. A piece of sheet or corrugated iron can be used on the top of the furnace flue, which is then covered with a layer of earth. Similar pieces of iron can be used, if the soil is light, on the sides of the trench, to prevent the earth falling in. An inverted kerosene tin is sus-

pended over the chimney to act as a baffle to prevent sparks coming in contact with the walls and with the rubber. Perforations are made by means of a nail, round all sides of the tin, from the open end (bottom) and to about half way up, to assist distribution of smoke.

On coastal estates where the water-table is high, an underground furnace is not advisable. On such sites, a small second-hand drum can be used as a furnace inside the smoke-house, retaining the kerosene tin as a baffle over the drum in which the fuel is placed.

In order to economise in space, if a drum furnace is used inside the smoke-house, a trench can be dug through the ground under the smoke-house and extending about one foot outside the walls, provided the bottom of the trench is above the water level. The drum can then be placed inside the smoke-house, so that its top is at ground level or just above. The object of the trench is to provide air for the combustion of the fuel. Baffle plates of corrugated or sheet iron or even pieces of wood can be placed in the trench outside the house to regulate the amount of air. These baffle plates can be raised on a loose brick or placed at an angle according to the ventilation necessary to keep the fuel burning slowly.

Only small logs of wood—a mixture of jungle wood and dry rubber trees (wood from trees which are cut down, owing to disease etc.) should be used as fuel. The logs should not be allowed to burn fiercely but to smoulder gently to produce both smoke and heat. Since no night smoking is usually done in small-holders' smoke-houses, a final log can be added about 8 p.m.

Ventilation

In the drying and smoking of rubber, ventilation is required in the smoke-house to carry off the smoke and moist air. Two roof ventilators, constructed of thin wood, sliding in a frame, are shown in Plates 1 and 2, but it is only necessary to cut two square or rectangular flaps in the hessian on opposite sides of the roof, so that the hessian can be rolled back like a blind to leave an opening. Similar flaps should be cut on three sides of the walls about three to four inches from ground level. A few trials will soon determine the amount of ventilation required for optimum drying and for producing a sheet which is not too dark in colour.

Floor

The floor can be of clean sand or clay which is pressed down.

Racks

A smoke-house of the size shown will contain two rows of *berotics*; the lower should be about four feet above the furnace and the higher about 1 foot 9 inches above the lower.

Each row will contain ten bertam or bamboo *beroties* about $\frac{3}{4}$ to 1 inch in diameter and spaced about two inches apart each of which will hold three sheets, i.e. 30 sheets on each row. If the temperature is too high on the *beroties* in the lower row, immediately above the kerosene tin baffle, the space where the middle sheets are hung should be left vacant. If firing is carried out properly, however, the temperature should not be too high.

The *berotics* should be wiped with a dry cloth periodically to remove dust or soot. If the smoked sheet is "dusty" when removed, owing to particles of ash or soot, the sheet should be well brushed after removal.

Additional Protection from Rain

If found desirable, a protecting wall of attap or any cheap wood (from old boxes etc.) can be placed all round the house to a height of about 7 feet. The "wall" need not be carried to the ground level but can stop at about two feet from the ground.

Costs

The figures given below are the average costs obtained from the erection of a number of these smoke-houses used for demonstrations at various District Agricultural Shows. The erection was supervised by a Rubber Instructor. The materials were purchased locally and local labour was employed.

Many small-holders will be able to erect a smoke-house without employing outside labour and may also be able to obtain the materials at a lower cost.

Labour	$1.50
Poles or bamboos for frame	1.20
Gunny bags for walls	1.50
Galvanized iron for flue and furnace	0.85
Attap and Rotan for tying	0.50
Kerosene tin	0.20
Meranti wood for door frame etc. ...	0.75
Material for treating walls	0.30
Beroties	0.30
Hinges for door and nails	0.40
	$7.50

Alternative Construction

A criticism of this smoke-house has been raised to the effect that rubber can easily be stolen from it at night, by cutting the hessian. It is not considered, however, that the question of stealing is of great importance, since all small-holders who at present market only air-dried sheet, have to bring the sheets into their own houses at night to prevent theft, and if there is risk of theft from the smoke-house, the sheets of drying rubber can also be kept in the house at night.

The reason for using hessian for the walls of the smoke-house is because it is cheaper than other materials. Other cheap materials that may be used instead and which would offer greater protection from theft of the rubber are (a) split bamboo (b) cheap wood, (c) galvanised iron or tinned iron from second-hand kerosene tins, and (d) expanded metal with hessian.

An objection to the use of galvanized iron from second-hand kerosene tins is that metals radiate heat and are not so desirable on that account for the construction of smoke-house walls as wood or other insulating material, especially when no firing is carried out during the night. If expanded metal with hessian outside is employed, a piece of expanded metal 10 ft. × 8 ft. can be bent and used for three walls 3 ft. × 3½ feet, which can be embedded in a trench about 1½ feet deep, so that walls above ground are 6½ ft. high. Another piece of expanded metal 8 feet × 6 feet is sufficient for a door 6 feet × 3 feet which will form the fourth wall and also provide sufficient material for the roof.

The use of such expanded metal will amount to about $6/- and thus double the cost of the house.

These alternative materials are described for the benefit of small-holders who are able to spend more money on construction.

Remarks

Small-holders can obtain the services of the Rubber Instructors for advice and assistance in constructing these houses.

Kuala Lumpur

26th July, 1935

NOTE ON THE DETERIORATION OF RAW RUBBER BY MANGANESE CONTAMINATION

BY

J. D. Hastings and E. Rhodes

Introduction

The presence of excessive amounts of manganese has been found by Bruni and Pelizzola (1) to be associated frequently with tackiness in raw rubber. Bishop and Sekar (2) have described the development of unusual stickiness when rubber prepared from latex to which manganese salts had been added was subjected to a temperature of 50—55°C for 300 hours. More recently Sackett (3) has found that the use of manganese salts in the manufacture of crude rubber gives a product which becomes tacky and weak on storage and which, when vulcanised, has a lower tensile strength, a poorer age-resistance and a poorer abrasion-resistance than a normal rubber. Bruni and Pelizzola when examining various samples of very tacky estate rubber found amounts of manganese of the order of 0.02 per cent, but were not able to form firm conclusions as to the manner in which such large amounts of manganese find their way into various grades of estate rubber. The present note describes an instance in which it has been possible to trace the cause of serious manganese tackiness in a large consignment of estate rubber.

Experimental

A large American consumer reported that a consignment of 150 cases of smoked sheet rubber from a Malayan estate had developed such very serious tackiness in the course of a storage period of two years that it had become virtually useless. It was stated that manganese had been detected in the rubber in amounts of the order of 0.01 to 0.02 per cent. Samples of the rubber were forwarded to the Institute for confirmatory test and when examined were found in the worst cases to contain amounts of manganese of the order of 0.026 per cent, thereby confirming the findings of the American investigators. As the producer's name was known it was possible to attack the problem at its source and to attempt to discover the real cause of the high manganese content of the rubber.

When the estate was visited, it was found that no chemicals containing manganese were in use, nor had such ever been em-

ployed in the manufacture of the estate's rubber. There remained the one possibility that the estate water supply might contain manganese, but this possibility seemed somewhat remote because, of the many samples of Malayan estate factory waters that had been examined at the Institute over a period of years, none had been found to contain dangerous amounts of this element. The matter was however investigated. The estate had three separate sources of water of which one was used only in emergency, during unusually dry weather. Water from this particular source had actually been in use in the factory about the time that the rubber under complaint had been prepared. Samples were drawn from all three sources. The water from the two more commonly used sources was found in both cases to be free from manganese but it was present in remarkably large amounts in the water from the emergency source. This water had a pH value of 5.4 and was therefore distinctly acid. The content of total solids on the filtered water before and after ignition was 131 and 103 parts per 100,000 respectively. It is unusual for samples of Malayan waters to possess such a high total solid content and this fact in itself would throw some suspicion on the quality of the water in question. Tests for manganese indicated its presence to the extent of 22 parts per 100,000 and it therefore seemed very probable that this water was the direct cause of the deterioration of the consignment of rubber under reference. It was necessary however to find reasonable evidence that the water and not the latex itself was responsible for the trouble. It was therefore considered desirable to prepare at the Institute an experimental batch of rubber from latex known to be above suspicion, using the manganese-contaminated water for rubber prepared from the same latex diluted with and soaked in a satisfactory water. Supplies of manganese-contaminated water were brought to the Institute, where two experimental batches of rubber were prepared from Institute latex, diluted to 1½ lb. dry rubber per gallon with

(a) manganese-contaminated water and

(b) Institute water free from manganese.

The latex was coagulated in each case with 2¾ fluid ounces of 5 per cent acetic acid per gallon and the rubber was machined into sheet on the following day between dry rolls. The wet sheets were then soaked in water for one hour before hanging to drain for two hours and before drying in hot air at a temperature of 125 °F for 64 hours. Manganese contaminated water was employed as the soaking medium for the rubber of batch (a), and Institute water free from manganese was used for batch (b).

When freshly prepared and also on arrival in London neither of the two batches of rubber exhibited any trace of tackiness, and

although the "manganese rubber" was slightly darker than the non-manganese or control rubber, it would have been classed by present day visual standards as first-grade rubber.

It was expected that the "manganese rubber" would show a greater tendency towards deterioration by oxidation than the control rubber and the following tests indicated this to be so:—

(i) Hardness (D30) after heating in air for 18 hours at 100°C.

TABLE I

Sample	Hardness D30 mm.	
	Initial	After 18 hours at 100°C
Control	1.47	1.66
"Manganese Rubber"	1.43	0.87

It is seen from the above test that whereas the control sample hardened slightly in a normal manner under the influence of heat, the "manganese rubber" softened very markedly.

(ii) Ease of Mastication

The following figures indicate the number of grindings required to reduce each of the two rubbers to a fixed plasticity.

TABLE II

Sample	Mastication Number
Control	98
"Manganese Rubber"	80

The greater ease of mastication in the case of the "manganese rubber" indicates a greater tendency towards oxidation.

(iii) Oven-Ageing of vulcanised Material.

TABLE III

"Manganese Rubber"				Control Rubber			
Time of Vulcanisation at 148°C.	Period of Ageing at 70°C	Tensile Strength at break	Elongation at load of 1.04 kg sq.mm	Time of Vulcanisation at 148°C	Period of Ageing at 70°C	Tensile Strength at break	Elongation at load of 1.04 kg sq.mm
min.	hours	lb/sq. in.	per cent	min.	hours	lb/sq. in	per cent
117	0	1650	863	112	0	1740	865
	48	1490	745		48	2050	766
	72	620	—		72	1650	705
	96	240	—		96	350	—
	120	190	—		120	250	—

The "manganese rubber" is seen to be throughout weaker than the control and perishes in a shorter time. The observations by Sackett (3) and those now presented are therefore in agreement.

Discussion and Summary

A manganese-containing water supply has been found responsible for a serious complaint of manganese deterioration in a large consignment of raw rubber which had been stored for a period of two years. Manganese-contaminated rubber may possess initially, and retain for several weeks, the appearance of first-grade rubber, but experiments have indicated that, because of the greater ease with which it oxidises, the danger of the development of softness and tackiness on long storage is greatly increased. It is important that on no estate should manganese salts be employed in the preparation of rubber. If complaints should be received as to tackiness in first-quality rubber, water samples should be despatched to the Institute for examination.

Acknowledgment

The rubber samples were examined by the staff of the London Advisory Committee, who provided all the results of the tests on the quality of the rubber.

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Kuala Lumpur,

2nd January, 1935

BRASS WIRE GAUZE FOR STRAINING LATEX

BY

B. J. Eaton

As a result of the exhibition of a specimen of the usual estate latex strainer with brass wire gauze at the recent Rubber Exhibition held at the Science Museum, South Kensington, our attention has been drawn by the Research Association of Rubber Manufacturers, and the London Advisory Committee for Rubber Research (Ceylon and Malaya), to the possible danger arising from the use of such sieves in relation to the contamination of latex and raw rubber with copper. It has not apparently been realised that sieves with brass wire gauze have been universally used on estates in the rubber-producing countries of the East since the rubber plantation industry was started. It is generally known to all producers that the presence of very small amount of copper salts present in raw rubber produces tackiness.

As a rule, when copper is found in raw rubber it occurs in spots or small patches which are caused by local contamination.

Complete tackiness of a sample of raw rubber is only caused by dipping or soaking the rubber in a solution of a copper salt or by copper contamination of the latex.

Very minute amounts of soluble copper salts (about 0.001 per cent) have an extremely bad effect on manufactured rubber articles and cause rapid ageing of such articles.

In the case of tacky spots in raw rubber caused by contamination with copper, the metal may be contained in the oil from the bearings of a machine.

In the case of one estate sample of an otherwise good quality lower-grade crepe which contained a number of tacky spots found to be caused by contamination with copper, the copper was traced to portions of the massed wire of a brass sieve embedded in the corrugations of the creping rolls. In this case the wire from the sieves had probably been carelessly embedded in a mass of lower-grade rubber passed between the rolls of this machine.

If the wire gauze of sieves has become corroded and verdigris (green copper salts) is present, this will contaminate any latex passed through the sieve and is practically certain to produce tackiness in the raw rubber or to *cause it to deteriorate more or less rapidly even if no tackiness is indicated* at an early stage. Great care should therefore be taken to ensure that the wire gauze is clean and in good condition before latex is strained through it.

Preserved Latex and Copper Contamination

In some cases ammonia is added in the field to latex which is to be shipped as normal or concentrated latex. Attention is specially drawn therefore to the danger of straining latex containing ammonia through brass wire gauze sieves, owing to the solvent action of the ammonia on copper.

The importance of using other materials in the place of brass wire gauze when dealing with ammoniated latex may not be sufficiently realised by all producers.

In no case should latex containing ammonia be strained through brass wire sieves. It is recommended that only stainless steel wire gauze should be used for straining ammoniated latex.

Possible Alternatives

Investigations are at present being carried out in the laboratories of the Institute with other metal gauzes such as stainless steel, nickel and monel metals. Unfortunately wire gauze of these materials is considerably more expensive than brass wire gauze. Stainless steel is the most expensive but its use is advocated for the straining of latex which is exported in the form of normal or concentrated latex.

Effect of Copper on stored Rubber or Latex

Even if the amount of copper in raw rubber is not sufficient to cause tackiness at an early stage, the effect of very small quantities in rubber (or latex) which is stored for a long period may be very deleterious in respect of the ageing of rubber articles manufactured from such rubber or latex. As in the case of the slow effect of manganese contamination, very minute amounts of copper may cause deterioration in the case of stored raw rubber or latex.

Further Investigations

A further article giving the detailed results of investigations will be published in a later number of the *Journal*.

It may be essential to ascertain whether contamination of raw rubber with copper is by any means general. Authorities who have been consulted in Netherlands India consider that the danger of copper contamination in the past due to using brass sieves, has been small.

Kuala Lumpur,
19th July, 1935.

OIDIUM HEVEÆ

Report on the 1935 Outbreak of Hevea Leaf Mildew

BY

F. Beeley

During the early part of 1935 Malaya has experienced a return to more normal weather conditions. The easterly winds following the north-east monsoon rains brought with them a period of very bright, dry weather during most of January and the first half of the month of February. A period of drought coming at this early part of the year is considered ideal from the point of view of inducing the fall of old leaves and production of new ones -a natural function observed in all deciduous trees, even in tropical regions, and known locally in connection with rubber agriculture as "wintering."

As a consequence of this pronounced period of dry weather wintering was early in practically every part of the country, the exceptions being some local coastal areas, especially the Dindings and Matang, where local weather conditions appear to be affected by the close proximity of the Hijau and Bubu mountains, and the Labu—Port Dickson district where again local weather is affected by nearby mountains. It was in these districts from which the earlier report of the presence of the disease arrived. The winter ing generally was sharp and even, while in the northern districts refoliation was almost complete before the weather broke. In the central and southern States up to 50 per cent of the trees had obtained their new leaves by the middle of February and it was thought that Malaya would escape the Leaf Mildew disease entirely. However, on the 14th of February a distinct change in the direction of wind occurred and several dull cloudy days with light rains followed, giving opportunity for the fungus to develop and attack the young leaves of the late-wintering trees.

This dull weather continued for several weeks but intervals of bright sunny weather speeded up the refoliation and prevented the disease from attaining a virulency sufficient to cause any serious defoliation.

As a consequence of this intense and even wintering the new foliage is brighter, more even and more dense while the number of seed pods set is greater throughout the country than has been the case for some years past, and if the return to normal climate is maintained there is every reason to hope that the improvement

in the foliage of rubber trees in Malaya will be continued next year.

Whereas last year the earliest reports of the disease were received in March, this year (1935) reports were received in February, while the greatest number of reports were received during late February and early March when the weather was dull and showery. Later the weather became brighter, with the consequence that few further reports were received except from the coastal districts of Selangor where, owing to the peaty nature of the soil, wintering had been later and more desultory. In practically every case the reports indicated a very mild attack with slight leaf-fall on late-wintering trees only. Reference to Table I and the graph will indicate the time of first-noticed leaf-fall in the various States and the number of reports received during the season.

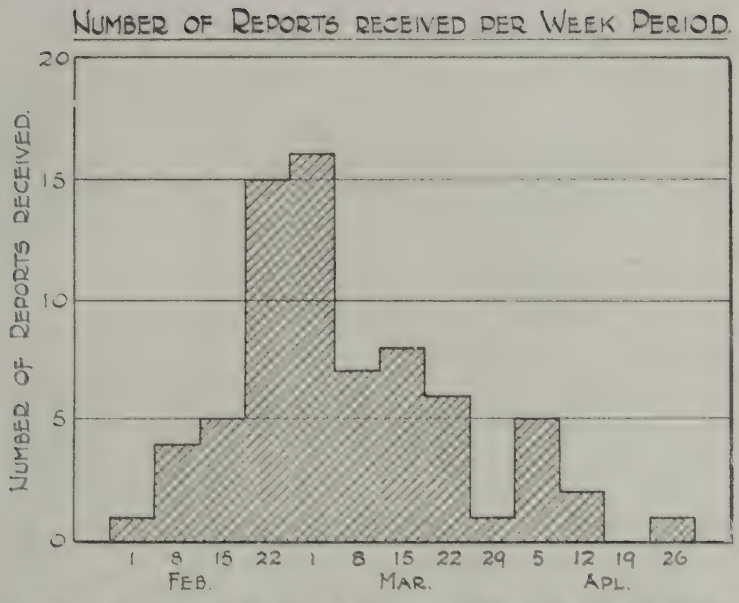
TABLE I

Oidium Heveæ 1935

Reports received per Week from each State.

	February				March				April					
	1 — 8	8 — 15	15 — 22	22 — M. 1	M. 1 — 8	8 — 15	15 — 22	22 — 29	29—Ap. 1	5 — 12	12 — 19	19 — 26	26 — M. 6	TOTAL
Johore				2	7	1	2	2						14
Malacca					1			1						2
Negri Sembilan	1	3	1	5	1		1			1				13
Selangor		1	2	4	2	1	1	2	1	3	2		1	20
Perak				4	3	5	3	1						16
Province Wellesley			1											1
Kedah			1		2									3
Pahang							1			1				2
Total	1	4	5	15	16	7	8	6	1	5	2	0	1	71

During March the writer visited every rubber-growing district west of the main range and full notes were made of the condition of the foliage and extent and virulence of the leaf mildew disease at that time. These notes together with observations and



information supplied by estate managers form the basis of the district reports given below.

While on this tour of the districts a disease resembling Oidium leaf mildew, but in this instance caused by what was at first thought to be the leaf mite *Tarsonemus translucens*, was present in several districts and in some of the low-lying coastal areas was entirely responsible for the small amount of leaf-fall taking place in the mature rubber. Microscopical investigation showed this small insect to be a Thrips species and not a mite. A report on this new pest of rubber trees is given elsewhere in this *Journal*.

JOHORE

The beneficial effects of the early wintering and refoliation were obvious throughout the whole of this State and particularly in the central districts where the trees are well grown; by mid-March the trees had completely refoliated. The top foliage was very good and quite healthy, while in only rare instances was Oidium observed and was usually confined to the lower branches of a few backward trees.

The rubber trees nearer the coast are not so vigorous as those in the more central districts and, though the foliage is not so good, little evidence of leaf-fall caused by the disease could be found. Dense planting in some of the small-holdings in coastal areas gives the impression at first of very dense foliage.

North central Johore proved interesting in that, while the older mature rubber had wintered early and obtained a good new foliage, several fields of young rubber and some immature rubber which were observed to be wintering rather late had caught a heavy infection, giving a pale mosaic appearance to the leaves. The spread of the disease in this district may be due to the local rains or mist caused by the close proximity of Mount Ophir (4187 ft).

The occasional fields of rubber seen in the abandoned *lalang* areas around Yang Peng and Ayer Itam are not reported upon here.

Malacca

In the northern part of the territory where, owing to impoverishment of soil, the rubber is poor and stunted, almost 100 per cent early wintering had taken place with the result that a new foliage, free of disease, and in appearance the best seen in the district for many years, developed.

In the more central districts the rubber improves and areas may be found where the foliage is dense and of a glossy dark green colour showing little evidence of mildew, though on closer inspection the lower, heavily-shaded branches were observed to be infected.

The rubber on the undulating country inland around Tampin, Kemuning and Batang Malaka had, following a severe wintering, developed a better and healthier-looking foliage than has been the case for many years. Occasional areas of young rubber which had developed new leaves rather late were seen to be infected with the mildew fungus.

In the southern coastal districts of the territory also a great improvement of the foliage was noticeable. The crown foliage was in almost every case of good colour and free of disease while in the lower branches traces of infection and slight leaf-fall were observed. Contrary to last year the rubber in the coastal areas seemed to be in better condition than in the Jasin district. Around Jasin wintering appeared to have been late and irregular, possibly due to the fact that a secondary wintering in August was experienced in 1934. Most of the late-wintering trees had Oidium in the lower and middle branches but only a slight leaf-fall was evident. This situation is possibly due to the proximity of Mount Ophir.

The Asahan district appears to have been protected by the same hills and had wintered at an extremely early period and according to information many of the trees developed new leaf in January. The district is now practically free of leaf-fall and

on only rare occasions was the fungus found at all. The foliage is a great improvement on last year.

Negri Sembilan

The coastal district of this State had a varying type of foliage due apparently to variations in soil nutrition and water supply. Some of the gravel and quartz soils bore rubber of rather poor foliage in which a considerable amount of disease and leaf-fall was present caused both by Oidium and by Thrips. Here again a secondary wintering was experienced during the drought of August last. A great improvement was noticeable further south where an early and even wintering had resulted in an excellent foliage. Occasional patches on gravelly soils were seen to be affected by the mildew disease but in very few cases was leaf-fall observed. Similarly in the Lukut area, in stunted rubber on badly-drained flats, the disease was in evidence.

In Port Dickson, Linggi and Sengkang districts some fields were observed to be as bad as last year, due to a late desultory wintering. A secondary wintering in August last again appeared to be responsible.

A considerable improvement was observed more inland and also towards the Lubok China districts where such leaf-fall as was observed was found to be due to Thrips.

Inland, Siliau & Rantau districts had experienced a severe early wintering on the undulating and hilly land with a consequent good foliage. On the flats several fields were observed to be infected sufficiently to cause leaf-fall from the middle and lower branches. Seremban, Labu and Nilai districts showed a very good foliage with only occasional late-wintering trees carrying a light infection with slight leaf-fall from the lower branches.

In these districts a considerable amount of sulphur dusting had been carried out, but the effects of the disease have been so slight this year that no visible improvement to the foliage had been obtained by four weekly rounds of sulphur dusting. Throughout these districts Thrips were observed to be active on the new shoots and whorls of leaves in both mature and young areas. In the Nilai district some small areas of badly diseased foliage were observed which may have been due to local conditions affecting the wintering and refoliation.

In the Gemencheh district an early even wintering had in nearly every case led to a good healthy crown of foliage, whereas in Johol considerable areas of late-wintering trees had been attacked but even so the foliage showed a great improvement on last year.

Selangor

The rubber generally on the higher ground in this State had a very early and intense wintering, with the result that much new foliage was obtained before the fine weather broke in the middle of February. In the more fertile, watered valleys wintering was not so early and in such areas the late-wintering trees could be observed in late March to be suffering from a mild attack of Oidium in the lower branches.

In the coastal districts the wintering was not so severe and infection, causing a scarcely noticeable leaf-fall, was observed, together with a fall of young leaf caused by Thrips sp.

The southern coastal district contains areas where the foliage looks poor on account of poor soil conditions.

Further inland around Kajang, Kuala Lumpur and Kuala Kubu the wintering was generally very early but, owing to the presence of mists around the foothills, the late-wintering trees were attacked in March and early April. Even so the foliage this year can be said to be more dense and of a deeper and brighter colour than in 1934.

Further north towards Tanjong Malim the improvement in foliage was maintained; trees on the hilly land wintering early had developed an excellent foliage but again those in the valleys were suffering a mild attack, actual leaf-fall being confined to the lower branches of late-wintering trees.

The northern portion of Selangor also showed a general improvement though in several places the activity of Thrips pest was noted.

It is of note that this year the greatest number (20) of reports were received from Selangor, but it is gratifying to note that in most cases the outbreak was described as of a mild nature confined to small areas of the State. This is borne out by the great increase in number of seed pods which are evident upon the mature rubber.

Perak

The trees in the district north of Tanjong Malim had experienced a severe early wintering and developed a good foliage by the end of March; Trolak generally showed a great improvement on last year and the quality of the foliage seemed to vary with suitability of soils. Contrary to last year there were scarcely any signs of leaf-fall due to *Oidium Heveae*.

The undulating ground of Sungkai bore rubber of heavy foliage and was practically free of disease.

Further north from Bidor throughout the Kinta district the quality of the foliage varied with that of the soil. Trees on the

hills bearing excellent foliage practically free of disease were in evidence while on the alluvial flats the foliage though poor was healthy. Other occasional areas on rich flat land showed an excellent foliage, but new shoots and whorls of leaves were found to be infected.

The trees in the Kinta district as a whole showed a great improvement in foliage over previous years.

The foliage in the Ipoh-Chemor district though better than last year was, owing to the alluvial nature of the soil, only of medium density. Very little evidence of disease could be found, even the young clearings were looking very healthy.

Sungei Siput and Padang Rengas districts showed a much better foliage which appeared to have escaped attack completely although new shoot growth proved on close examination to be infected. Here also an early, severe wintering had taken place.

North Perak, owing to the configuration of the land showed extremely variable foliage. On one side of a hill the trees had wintered early and obtained an excellent foliage while on the other side late wintering and consequent attack of leaf mildew had occurred. Further variation in quality of foliage was due directly to soil conditions, the substratum in some places being solid rock.

Leaving the hills to the territory west of Gunong Semanggol and Gunong Bubu more normal conditions were found and a gradual improvement had taken place until on the flat peaty soils a very heavy dense canopy of foliage was general.

Further south the wintering had been upset by local climatic effects due to the proximity of G. Bubu. Wintering was patchy and, though some areas had developed a fairly good foliage, others showed a heavy infection with resultant heavy leaf-fall. This district was the worst observed during the tour. A gradual improvement took place further south in the Bruas district, but wintering had been patchy and some 5 to 10 per cent of trees in the early stages of refoliation were observed to be heavily infected. The improvement was continued in the rubber in Sitiawan, where wintering was more even and complete, though in many cases the lower branches had been attacked and suffered considerable leaf-fall. Even so the canopy was somewhat better than that of last year.

Lower Perak, which has rarely shown any evidence of leaf-fall, has this year remained practically free of mildew disease.

Province Wellesley

Conditions here were similar to those of last year and though the foliage was said to be slightly heavier a slight attack of leaf

mildew had been experienced in mid-February, but a complete recovery had taken place in both the old and the young rubber. At the time of the visit slight infection of new whorls of leaves was noted.

On the poorer hilly land near Bakap some areas of poor rubber were observed to carry a moderate infection causing mild leaf-fall. Further inland the rubber is planted on rising ground intersected by padi lands and on the whole was in good condition and showed no signs of having been attacked.

KEDAH

In South Kedah the Terap and Serdang districts appeared to have escaped attack completely. Difficulty was experienced in finding the slightest trace of the fungus even on the new shoot foliage. The conditions of the foliage varied entirely with the general cultural conditions.

Further south towards Bandar Bahru, though the upper foliage was good, distinct signs of infection and leaf-fall in the lower branches was noted.

In the Kulim district the trees in both large estate and smallholdings had a dense canopy of deep green foliage. Secondary growth on lower branches was attacked by the Oidium fungus. Similarly in the Lunas district early wintering had resulted in excellent foliage which appeared to vary only according to the soil conditions.

Around Padang Serai early wintering had resulted in a strong dark green foliage in most of the rubber areas. Secondary growth appeared to be attacked by both Oidium and Thrips. Kuala Ketil and Lubok districts also showed a great improvement on the foliage of last year, though a few late-wintering trees had been caught by the disease following the break in the weather just after the middle of February. The young rubber trees, late wintering trees, and the new growth on refoliated trees were here shown to be affected by both *Oidium Heveae* and Thrips.

The foliage in the Kuala Muda and Sungei Patani districts was considered to be some 50 per cent better than in the previous two years; early wintering of the trees on the hard soils enabled them to escape attack during refoliation, resulting in good well-shaped dark green foliage. Grass-covered fields invariably bore an inferior foliage.

The improvement continued further north to Gurun, the most northerly point visited. Here the foliage was, as usual, very heavy and as a result of the excellent shade Oidium, Thrips, spider and Helminthosporium leaf spot were observed in the new growths

of the lower branches. Local strong winds were also responsible for the fall of leaves or stems bearing whorls of leaves.

PAHANG

It would appear that in the western districts of Pahang the early wintering had ensured a canopy of foliage almost free from disease and any variation in foliage could be attributed to variations in soil condition. Oidium and Mites or Thrips were reported to be active in the later growth of new foliage, but generally the foliage may be said to be better than in the previous few years.

Summary

The fine dry weather experienced during January and February induced an early wintering of rubber trees in Malaya with the result that a large percentage of the trees had obtained a good healthy crown of foliage before the break of the weather and advent of conditions more suitable to the mildew disease.

The foliage and seed harvest this year are a great improvement on the last few years.

Only in isolated localities has the fungus caused a mild leaf fall, usually found to be due to differences in local climatic conditions caused by the proximity of mountains.

The great benefits to be derived from a dry, sunny wintering season are indicated by the improvement in both health and density of foliage of rubber trees as a result of the present year's experience.

Owing to lack of virulence of the mildew fungus under such conditions the sulphur-dusting experiments carried out in various parts of the country have indicated no decisive improvements in foliage or yield of rubber following such treatment.

Kuala Lumpur

10th July 1935

HEVEA THRIPS

Note on a new Pest of Rubber Trees

by

F. Beeley

History

In March 1935 what was thought to be a severe outbreak of *Oidium Heveae* was observed to be causing a serious loss of the young leaf of rubber trees on the Institute's Experiment Station at Sungei Buloh. On investigation, however, the leaf-fall proved to be due to a very tiny insect of the genus *Thysanoptera* and for convenience has been called Hevea Thrips. The occurrence of a similar insect on mature rubber in many other districts was confirmed and it was obvious that the leaf-fall in the coastal districts which had been attributed to mites was in reality due to *Thrips* sp. These insects are so small—when full grown they are little more than 1 millimetre in length—that they are at first easily confused with the common rubber-leaf mite *Tarsonemus translucens* which by sucking the cells of the leaf-vein gives rise to symptoms very similar to those of Thrips damage.

Hevea Thrips was found to be particularly active on the very young leaves produced immediately after wintering. According to Dammerman (1) several species of Thrips are known to cause more or less serious damage to crops such as maize, sugar cane, tea, rice, tobacco and vegetables in the Malayan Archipelago.

Description of the Insect

The insect is of typical Thrips structure varying in size from one half to a little over one millimetre in length. An average winged specimen had the following measurements: Length of body only 0.96 mm., length of body + antennæ 1.1 mm., wing span 1.2 mm., antennæ joints 5. In colour they are pale, brownish-red to flesh-coloured or buff. The winged forms are comparatively rare, considering the large numbers of nymphs which may be found on a single leaf.

A diagrammatic illustration in Plate 1 shows the winged insect and nymph.

Insects of this type have specially modified mouth-parts which enable them to puncture the cells of the leaf and thus suck up the fluid cell-contents. The veins are, naturally, the chief object of attack and with continual puncturing the cells of the veins of a

Hevea Thrips—The Winged Adult and Nymph

Hevea leaves following attack by Thrips (left) and by Oidium (right)

Leaves attacked by Thrips

Note the typical silvery appearance of the leaves and the formation of the excrement

leaf which recovers from the attack appear to become meristematic and a new vein is developed alongside the old one. If the attack continues the veins become wide and flattened, having a fasciated appearance.

Symptoms of Attack

The method of attack results in symptoms somewhat like those of Hevea leaf mildew; indeed the two may often be found together. Oidium spores may often be found adhering to the legs and body of these insects. The young leaf, only a few days old, is strongly favoured by these insects and, as in the case of attack by Oidium, the young leaves may fall before they attain a length of two to three inches. The leaf-fall appears to be accomplished naturally by the tree which, owing to the excessive evaporation of water from the leaf, is induced to form an abscission layer across the base of the leaf petiole, after which it is only a matter of a few days before the leaf falls off.

Thrips-infested leaves which have fallen to the ground may be distinguished by the prominent brown or blackish veins, the colour being due to early decomposition of the punctured cells of the veins.

The insect appears to feed chiefly in the region of the veins on the underside of the very young leaf. In so doing growth of the lower side of the leaf appears to be checked while the upper side continues to grow at nearly normal rate which causes the leaf, should it survive, to become concave on the underside or in cross section like an inverted 'u'. If the leaf survives for three weeks or more it assumes the shape of a scoop or elongated spoon, the concavity being below, which is exactly the reverse of a leaf surviving an attack of *Oidium Heveae*, where a strong cork phellogen is developed over the wounded veins on the underside of the leaf which, as growth proceeds, bends the leaf lamina on each side of the central vein sharply upwards or in section thus 'V'. The patch of cork developed on the veins of leaves attacked by Oidium is distinctly reddish-brown; on leaves attacked by Thrips there appears to be no cork formation, a new vascular system being developed alongside the old, giving the fasciated appearance mentioned above.

General Observations

The intensity of attack appears to depend upon the number of young leaves present and the state of wintering and refoliation. The pest is more serious in young rubber than in old, though a few trees of over 20 years of age, which have been kept under

observation from March to July this year, have still failed to set a satisfactory foliage, each burst of new leaf having been severely attacked by Thrips.

On the Experiment Station areas were observed where three- and four-acre groups of trees, wintering simultaneously, had suffered a very heavy attack resulting in complete defoliation of the trees such as is rarely seen, except in individual trees, in the case of trees attacked by *Oidium Heveae*.

The insects appear to be most active in fine weather, or in bright showery weather following a fine spell such as is experienced in Malaya before the wintering season. During such weather hundreds of the wingless nymphs may be observed feeding on a single leaf; on several leaves examined the veins on the underside were obscured by masses of these insects.

Plates III, IV and V illustrate the extent of damage which can be caused by this insect.

Control

Control may be accomplished by the use of copper or sulphur dusts. Two rounds of sulphur dusting, by means of a motor duster at the rate of 5 to 6 lb. per acre checked the activities of the pest on the Experiment Station to an extent which enabled the trees to develop a satisfactory foliage.

The use of liquid sprays would be out of the question owing to the high cost and practical difficulties such as power and water supplies.

Summary

An account is given of a new Thysanopterous pest of rubber trees in Malaya which is provisionally called Hevea Thrips. Under favourable conditions Hevea Thrips may cause a serious leaf-fall similar to that caused by *Oidium Heveae*. The general appearance of the insect and symptoms of attack are described.

The pest may be controlled satisfactorily by the use of insecticidal dusts applied by means of a motor duster.

Description of Plates

Plate I. Upper: Line drawing of the nymph and adult insect × 45
Lower: Hevea leaf following attack by Thrips (left), and by Oidium (right)

Plate II. Leaves attacked by Thrips. Note the inward curling of the leaves and the fasciation of the leaf veins

Five-years-old Rubber Trees defoliated by Thrips

Five-years-old Rubber Trees defoliated by Thrips

Five-years-old Rubber Tree defoliated by Thrips

Plates III, IV & V. Photographs of five-years-old rubber trees defoliated by Thrips

Literature

(1) K. W. Dammerman *The Agricultural Zoology of the Malay Archipelago* 215

Kuala Lumpur,

15th July, 1935.

THE USE OF NATURAL COVERS ON RUBBER ESTATES

BY

B. J. Eaton

During the past two years a series of articles on the development of Natural Undergrowths on rubber estates has been published in *The Malayan Forester* [1], numerous letters have appeared in the local press, articles have been published by "Planting Correspondent" in *The Straits Times* [2], and an article entitled "Ecology in Rubber Growing"—a review of R.R.I. *Manual No. 6 The Uses and Control of Natural Undergrowth on Rubber Estates* by W. B. Haines, —has been published by "A.G.T." in *Nature* [3].

In view of various statements and criticisms contained in these articles, it appears desirable to discuss various aspects of the so-called "forestry methods" of cultivation. In this discussion no reference is made to the *results* of any specific investigations which are being carried out by the Institute, although mention is made of the work in progress at the Institute Experiment Station, on certain estates and on the area in the grounds of the Department of Agriculture, which is leased from the Government by the Institute.

In any discussion of this problem it should be emphasized that we are dealing with those aspects which concern the soil in relation to the growth of the plant, in respect of (a) methods for the maintenance of the fertility of the original soil after removal of the natural jungle flora and planting with rubber trees (b) the regeneration of deteriorated soils under "mature" rubber, where deterioration has been caused by erosion and other factors, particularly the destruction of humus and detrimental changes in the physical and chemical properties of the soil induced by prolonged clean-weeding, or by the cultivation of other crops before planting Hevea. It is mainly, however, with the latter aspect (b) of the problem that we are now concerned, since this is the principal subject of discussion in the articles under reference.

Furthermore it should also be emphasized that we are not concerned at the moment with the problem of natural rejuvenation of "mature" rubber areas by the development and selection of seedlings from seeds which fall from old trees.

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(1) See List on pages 65 and 66

(2) *The Straits Times* (1935) Jan. 18; June 1, 14, 21; July 12

(3) *Nature* **135** (1935) No. 3405 p. 168.

Nomenclature

It should be appreciated that this is essentially a soil problem. *It is of interest to both the forester and the agriculturist (or horticulturist)*, or whatever other title one wishes to apply to the cultivator of plants, and is a problem which we have stated previously to be definitely within the province of the soil scientist. It matters little whether the solution is ultimately found by the forester, the cultivator of trees for fruits or other produce, or the cultivator of vegetables or flowers.

In claiming this problem as one belonging to the realm of soil science, it is not suggested that it is not a "forestry" problem, since obviously the forester is as much concerned with the maintenance of soil fertility as the grower of "cultivated" plants. *Soil science is fundamental to both forestry and agriculture.*

Further, the student or scientific worker in soil science who has to apply his knowledge to the cultivation of plants (as distinct from the student or worker who may have only an academic interest in the study of the mechanical, mineralogical and chemical composition of soils or their geological origin) should have in addition a sufficient knowledge of other branches of science, particularly botany, to be able to apply his knowledge of soils to the requirements of plants. Any argument therefore that the study of this problem is concerned only with "forestry" or with "agriculture" is purely academic.

One writer has suggested the adoption of the term "Silviculture" for this practice; this is equally a misnomer, since this definition again embraces much more than the maintenance of soil fertility or the subsequent regeneration of a deteriorated soil by the development of undergrowth.

The chief objection to the use of such terms is that some "laymen" appear to consider that they apply specifically to "forestry" and not also to "agriculture" where the latter is concerned with the cultivation of a permanent tree crop. It is also overlooked that many of our cultivated crops were once "forest" products and their economic development has been the result of scientific study by the so-called "agriculturist" or "horticulturist".

Again, the question as to whether the rubber tree should be cultivated, as far as scientific advice and guidance is concerned, by a "Forestry" Department is merely a question of academic interest.

In a few small countries, departments of agriculture and forestry are still combined for the sake of convenience in administration. In larger countries these departments have been separated, on account of the very advanced economic development of certain specialised crops, because it would be difficult to control both in the same department. More recently it has been considered desirable to estab-

lish special organisations to deal with specific crops, e.g. The Empire Cotton Growing Association, the Tea Research Institute of Ceylon, the Coconut Research Scheme of Ceylon, the Tobacco Experiment Stations in Netherlands India, the Fruit Growing Institutions in Great Britain, the Pineapple Experiment Station in Hawaii, the Sugar Experiment Station in Java and the Rubber Research Stations in Sumatra, Java, Ceylon and Malaya. The principal disadvantage of such specialization is that some workers may develop a more narrow outlook and may not keep in touch with developments in other agricultural industries although these may have an important bearing on their own work. On the whole, however, it is realized that such specialization is of advantage in that research can be applied more intensively to a particular crop.

This brings us logically to a discussion as to the desirability of employing a "forester" in a rubber research organization. It has already been indicated that the problem of the regeneration of soil is essentially one for the soil scientist working in collaboration with the botanist. Whether a forester could provide any additional information of value is a moot point--so far he has not done so. It may be of interest to record that one large rubber planting organisation in the East formerly employed several foresters. This, however, did not induce this organisation to develop the use of natural covers on their estates.

In this connection one of the criticisms of A.G.T. in his article published in *Nature* to which reference has already been made is of interest. The statement on which A.G.T. bases his critcisms is contained in the "Foreword" in *Planting Manual No. 6* "The Uses and Control of Natural Undergrowth on Rubber Estates" and reads as follows:

> "For a study of this aspect of the problem the employment of a forester or Plant-Ecologist as has been suggested in some quarters is not essential".

A.G.T.'s criticism of the letter of this statement in reference to ecological studies in particular is justified and is caused by the method of expression used by the writer (B.J.E.). What it was intended to imply was that the Institute already had botanical officers who were qualified to investigate and advise on such problems and that any botanical officer attached to an organization such as the Rubber Research Institute, or for that matter to any agricultural institution, should have sufficient knowledge of ecological problems to be able to give advice or to carry out investigations.

For the information of those who may not be acquainted with the term, "Ecology" is fundamentally and scientifically the study of plants in relation to their environment. The study of ecology

is therefore one of the primary functions of every agricultural botanist as distinct from the specialist in systematic botany or anatomy whose interests may be primarily in the study of the classification of, or structure of plants.

It might be argued, for example, that because we occasionally send specimens of natural cover plants for identification to our colleagues of the Botanic Gardens in Singapore the Rubber Research Institute should also employ a Systematic Botanist.

This brings us to the subject of scientific titles or classification of workers, which some of us consider has been unnecessarily carried to somewhat extreme limits. A study of the list of agricultural scientific workers in the British Empire (including Great Britain) reveals the fact that among some 3,000 officers, there are only seven having the title of "Ecologist". One of these is a Chemist-Ecologist, whatever that may mean—possibly a combined Ecologist and Chemist or a Biological Chemist concerned with the investigation of plant products—while some of the others are professors combining the study and teaching of "Ecology" with other aspects of botanical science. The real fact is that the botanical officers of all the agricultural organisations usually styled "Botanist" or "Economic Botanist" are sufficiently cognisant of the principles of plant ecology to be capable of dealing with the practical aspects of ecological problems in relation to the crops with which they are concerned.

If A.G.T. and other critics desire, the title can be added to that of our present botanists. It may be desirable for the Governments of Malaya to add a botanical officer to the staff of one of the scientific departments for the general study of ecological problems in relation to waste lands—this is a matter on which no opinion is offered. As far as rubber estates are concerned, however, our own considered opinion is that the botanical and soils officers of the Institute are quite capable of dealing with the problems involved.

It is well known that A. G. T. (if we have identified him correctly) is one of the leading British authorities on ecological studies but his title is "Professor of Botany".

Present Knowledge of the Problem

It is now proposed to discuss briefly a few other statements and criticisms which have been published on this interesting and important problem of soil deterioration.

The following articles, having a bearing on the problem, have been published in *The Malayan Forester*:—

"Rubber Forestry Again" by J. N. Oliphant (Vol. III, No. 1, January 1934)

"Jelutong. Distribution and Silviculture" (Vol. III, No. 2, April 1934)
"Lalang and its Eradication" (Vol. III, No. 4, October 1934)
"Save the Vegetation" by J. N. Oliphant (Vol. IV, No. 1, January 1935)
"Clove Forestry" (*idem*)
"Ecology & Rubber-Growing" (Extracts from *Nature*) (Vol. IV, No. 2, April 1935)
"Foresters and Rubber Forestry" (*idem*)

Although the information contained in these articles is of considerable academic interest to agriculturists or horticulturists, who are engaged in the cultivation or study of permanent crops, as well as to the forester, none of the articles on rubber forestry contain any useful practical advice. It is not proposed to quote from these articles, except one statement to which exception can be taken on account of inaccuracy. In the article entitled "Save the Vegetation" the writer (J.N.O.) states "We in Malaya have seen the whole face of the rubber-growing industry transformed in the space of three years or so by discoveries in this field of two Danish planters with a flair for the practical applications of plant ecology, whose methods had a special appeal for the industry in slump time, owing to the element in them of *laissez faire*, and have lately received the rather tardy blessing of scientific authority. (The underline is the present author's). The writer (J.N.O.) is evidently not *au fait* with the situation. Even at the time that these two "pioneer" planters were experimenting with the regeneration of soils on their estates by the encouragement of natural undergrowth, the Institute was developing experimental areas on virgin soil by allowing natural undergrowths to develop. Another well-known planter, who is not a forester, was also at this early date developing his estate under natural cover plants. Correspondence in the Institute also reveals the interest taken in these early experiments.

The writer also well remembers that the first Director of Agriculture of the Federated Malay States nearly thirty years ago emphasized the dangers of clean-weeding on rubber estates. Unfortunately this opinion of the dangers of clean-weeding was not followed up by experimental work in the field. The slump in the price of the raw product has in this respect proved a "blessing in disguise" since it has compelled many estates to cease the practice of clean-weeding and to encourage the development of natural undergrowth.

Interesting, however, as are the articles which have been quoted as an academic discussion of the problem, in no case do they contain

any constructive recommendations which can be applied to the problem. Similar remarks apply to the numerous letters and articles which have been published in the local press. No blame, however, can be attached to the writers of these articles, since neither the forester, nor the agriculturist (or horticulturist), can at present, and probably will not be able for many years, lay down any general methods of procedure for practical guidance, applicable to the varying conditions.

The forester (in Malaya) is normally concerned with regeneration of planting material on soils which have not been deteriorated by clean-weeding. As far as the writer is aware the only soil regeneration experiment that has been undertaken by the Forestry Department is that described in the article "Lalang and its Eradication" quoted above. In this article the author expresses doubt whether the methods may prove applicable economically to the treatment of lalang areas for rubber cultivation. This, of course, is essentially an economic problem. In certain circumstances (low price of rubber or restriction of planting operation) it might be preferable to plant certain secondary jungle plants such as those described and to wait for five to seven years until these plants had superseded the lalang and had so improved the soil that replanting with rubber might prove successful. It will be realized, however, that at least ten or twelve years must elapse before any economic return would be obtained from such areas. Normally, it would probably be more economical to eradicate the lalang by digging at the cost of $40 to $60 per acre, to plant with the best available planting material of Hevea and to apply artificial fertilizers and develop either leguminous or natural covers to improve soil fertility with the prospect of obtaining revenue after six to seven years.

Soil Regeneration in Old Rubber Areas

The Planting correspondent of *The Straits Times* in a recent article has suggested that the Institute should acquire an old rubber estate in order to carry out experiments. This suggestion again shows a lack of appreciation of the problem. In order to study this problem, in common with many others involving field trials, the Institute would require possibly a dozen estates or areas in different parts of the country having different soil types, rubber of varying ages and soils showing varying degrees of deterioration. Each case has to be studied on its individual merits or demerits—and on this account it is our considered opinion that it is preferable to carry out experimental work on a number of estates throughout the country, by arrangement with the owners whereby the Institute agrees to bear expenditure for extra work and for

maintaining records, other than that normally incurred on the estate.

In one article (*Straits Times* 14th June 1935) Planting Correspondent states that the area belonging to the Department of Agriculture in Kuala Lumpur was acquired when the Institute came into being. Actually the area was first leased from the Selangor Government in 1932 for the purpose of tapping experiments. It was soon found, however, that yields were so variable that the area was of little use for this purpose. It was then decided to use a portion of the area as a convenient demonstration plot for the development of natural covers for the benefit of planters visiting Kuala Lumpur. This was not done, however, as Planting Correspondent states, "at his suggestion". Secondly, the area, owing to its previous history, was considered to be of value only for demonstration and not for experimental purposes. There has been insufficient time for the effect of any natural growths on the rubber trees to be instructive or interesting to the "practical" man. Also, since the area is held under Temporary Occupation Licence, renewable annually, and may be required by the Government at any time, it was not desirable to lay down any long-range experiments. Finally, what may prove interesting and valuable on this area may not apply to other sites.

As an illustration of the ideas that are held on this problem it may be interesting to refer to a letter received from the manager of an estate in the early days of the recent slump. His directors (in England) had written, allowing him x dollars and his labour force for a month to develop "forestry" conditions, after which he was to close the estate till the price of rubber improved. Knowing the area we unfortunately had to inform him that in his particular case, fifty years might be required. While admitting that the period suggested might be an exaggeration, our knowledge of the area enabled us to state that it would be many years before any desirable undergrowth could be developed on the badly-deteriorated soil on this particular estate.

Natural Undergrowth on New Areas

The Institute on its Experiment Station is also opening out new areas on experimental lines, on which natural undergrowths are allowed to develop with different systems of control, together with various types of leguminous cover plants on other plots for comparison. Several estates are also experimenting on similar lines. In a few years, therefore, valuable information will be available from areas on which such methods have been practised from the original felling of the jungle and opening of the estate. This

again is a problem distinct from that of the regeneration of deteriorated soils on "mature" rubber areas by the same procedure, since the natural undergrowth develops rapidly after the jungle is felled and before any soil deterioration has taken place.

It is possible that there may be a distinct retardation of growth of the rubber trees in the early stages owing to the competition of the cover plants. This has already been shown in experiments carried out with leguminous and natural cover plants at the Experiment Station. On the other hand the original jungle soil will have been preserved by the natural cover plants and erosion will have been prevented or considerably reduced.

Another aspect of the establishment *ab initio* of natural covers in areas planted with rubber from virgin jungle is that of the incidence of root diseases and white ants. Little is yet known in relation to this problem and much further observation and study is necessary. If, for instance, root diseases are merely retarded in relation to their attack on the rubber tree, and their effects are not observed until the trees are of considerable age, the final result will be disastrous, since with the extension of the lateral root system of the trees it may be found at a later stage that most of the trees are affected when treatment will be expensive and eradication impossible. On the other hand, the encouragement and development of natural covers *ab initio* may result in the prevention of such attacks on the main crop. These remarks apply to the development of new areas and not to the development of natural covers on "mature" areas which have been clean-weeded for years.

As far as tapping-panel diseases are concerned, *e.g.*, Mouldy Rot, a greater control may be necessary where natural covers are grown, owing to the damper environment.

Differences between Forestry Practice and Rubber Cultivation

Although it is not intended to discuss the aspect of rubber cultivation which implies regeneration by means of adventitious seedlings, it may be desirable to point out one important factor of this problem, which is overlooked by many planters and to some extent by the forester, *i.e.* the difference between the ultimate aims of the two. The forester's principal objective is the production of wood for timber and therefore he wishes to produce a large tree. The rubber planter's objective is to produce the highest yield of rubber from each tree. In this respect therefore our aim is not necessarily to produce a large tree but to produce the highest-yielding types, and therefore careful selection or manipulation (by budding) is necessary.

Rubber cultivation therefore in relation to this aspect of the problem is not "forestry". The forester has so far been able to pay little attention to improvement of his material by seed selection or vegetative propagation, on account of the economic aspect of the problem.

Natural Covers *versus* Fertilizers

Although it is not intended to discuss in this article the manuring of "old" rubber it is desirable perhaps to make a brief reference to the problem as an alternative method of improving the soil.

As in the case of recommendations for the establishment of natural covers, so in relation to the application of fertilizers to old rubber areas, each case must be treated on its merits. In some cases the manuring of old rubber may prove economical, in others it may be more advantageous to replant with high-yielding material and to apply fertilizers in addition to improving the soil by means of covers. Replanting is advised in particular on old areas on which root diseases are a limiting factor in the "economic" life of the old rubber. Where money is not available for manuring, recourse must be had to the slower methods of soil improvement by the development of natural covers. *A combination of both methods may be desirable in order to accelerate the improvement,* so that manuring and the development of natural covers are complementary. They do not represent opposite schools of thought as "Planting Correspondent" has stated in another article.

The problem of the application of fertilizers is obviously closely related to the future price of rubber and he would be a bold prophet who would venture an opinion on this. It is, however, known that much of our older rubber is deteriorating owing to bad practices in the past and that manuring, at any rate for a period, combined with the development of natural covers, is necessary to prevent further economic deterioration.

Conclusion

The writer is aware that this article contains no new information and no instructions or advice in relation to the problem under discussion. As stated at the beginning, the article is intended only as a general discussion of certain published articles and as a reply to statements and criticisms of the assumed attitude of the Institute to the importance of the problem. If necessary, it may therefore be again reiterated that the Institute is fully alive to the importance of the problem and has long since given its support to the practical application of the procedure. There is, however, no "royal road" to the practical application of the cultivation of

natural covers for the regeneration of soils on old rubber estates, hence it is impossible at this stage, and probably will be for some years, to publish any general recommendations. Unfortunately this is not appreciated by many critics, none of whom have yet made any *constructive* suggestions.

In relation to the problem of soil erosion and deterioration generally the reader is referred to other statements quoted in the *Annual Report* of the Institute for 1934 (Director's Report– Soil Investigations, pages 25/26) which show the importance attached to this problem of soil deterioration in other countries.

Reference may also again be made to the "Foreword" published in *Planting Manual No. 6* in which the various aspects of the problem in relation to the environment of the plant are stated and also to the general exposition of the problem as discussed by Haines in the *Manual*. These have not been and cannot be disputed or denied. They are as follows:—

(a) the retardation or prevention of soil erosion;

(b) the prevention of excessive run-off of rainfall so that more water is absorbed by the soil;

(c) shading of the soil to maintain the temperature below that at which excessive loss of humus occurs owing to oxidation;

(d) improvement of the surface soil layers in respect of humus content from the litter formed by continual decay of the natural covers;

(e) improvement of the percolating and water-absorbing capacity of the soil.

In relation to the ecological study of the problem, reference should also be made to the *Annual Report* of the Botanical Division of the Institute, 1933, p. 100, "Natural Cover Plants in Rubber Areas". The statement in this section is particularly relevant to A. G. T.'s criticisms on the question of identification of plant species.

Kuala Lumpur

19th July, 1935

BOOK REVIEW

"Rubber: Its Anti-oxidants and Preservatives" a bibliography compiled by the Science Library of The Science Museum, South Kensington, London, and the Research Association of British Rubber Manufacturers. *(Science Library Bibliographical Series No. 151, London 1934, Price 5/-)*

This publication, which is issued in mimeographed form, constitutes No. 151 of a series of bibliographies on various branches of science and technology which have been prepared by the Library of the Science Museum and has been issued on the occasion of the Rubber Exhibition inaugurated by the Rubber Growers' Association which is being held at the Science Museum from November 1934 till April 1935 inclusive.

This bibliography should prove of immense value to all workers engaged in research on the preservation of rubber, since it includes references dealing with the theory of anti-oxidants, storage of rubber, deterioration due to light and heat, water-absorption, general preservation of rubber and rubbers resistant to damage by oil and other liquids.

The importance of this subject in rubber manufacture and the rapid development in the application of numerous anti-oxidants and preservatives in modern processes of rubber manufacture is well known to all rubber research workers and is illustrated by the stream of new anti-oxidants which have been prepared during recent years.

The publication includes some fifteen hundred references indexed in accordance with the Universal Decimal Classification. The Science Library acknowledges the valuable help of the Nederlandsch Instituut voor Documentatie en Registratuur, Imperial Chemical Industries Ltd. and the Rijksrubberdienst of Holland in compiling this bibliography.

The publication also contains a list of the previous bibliographical series published by the Science Library and a list of periodicals on rubber chemistry and allied subjects.

December, 1934.

B.J.E.

BOOK REVIEW

"The Science of Rubber" EDITED BY PROF. DIPL. ING. K. MEMMLER, English translation by R. F. Dunbrook and V. N. Morris.

This book consists of pp. i—xvi + 770, including Author's and Translators' Preface, Table of Contents, List of Abbreviations of Literature consulted, Bibliography, Author and Subject Index and numerous illustrations. The book is published by the Reinhold Publishing Corporation, 330 West Forty-second Street, New York, price $15/- gold.

Numerous books have been published dealing with various aspects of the rubber industry, some of which relate only to the production of latex and/or preparation of raw rubber or plantation practice generally, while others are concerned only with the rubber manufacturing industry. The book under review which was compiled originally by Dr. Memmler and published in German under the title of *Handbuch der Kautschukwissenschaft,* has been ably translated by the present authors assisted by other members of the research staff of the Firestone Tire and Rubber Company.

The German author and his former collaborator—Prof. Hinrichsen—will be remembered as the joint authors of another excellent book entitled *Kautschuk und seine Prufung* published in 1910 when these workers were collaborating in the Materialprufungsamt near Berlin which testing station, corresponding to our National Physical Laboratory, the reviewer had the privilege of visiting in 1912.

The present book deals with both the production and manufacturing aspects of the rubber industry, although in relation to the latter only general principles and practices are discussed without any detailed descriptions of the technology of manufacture in respect of specific rubber articles.

The book deals very thoroughly with various aspects of rubber plantation practice—except diseases and pests—including the botany, cultivation, collection and preparation of raw rubber, the properties of latex and concentrated latex, the variability of raw rubber and factors affecting the variability. In the first section useful information is also given on latex and raw rubber, botanical features and other facts concerning trees other than Hevea species, from which latex and rubber have been extracted before the Hevea tree was developed as practically the sole rubber-producing tree in the Eastern tropics.

An important section is devoted to the chemistry of rubber, including the synthesis of caoutchouc and numerous rubber derivatives.

Other valuable sections deal with the vulcanisation of rubber, chemical methods of analysis of raw and vulcanised rubber, the physics of rubber and physical or mechanical methods of testing, with a final section on the microscopy of vulcanised rubber, its technique and application. The book also contains a valuable bibliography.

Both the original author and the translators are to be congratulated on the production of a book which is of great value to technologists (especially chemists and physicists) connected with the rubber-producing and manufacturing industry. The translators have also improved the original by many references to the latest literature.

The reviewer does not pretend to be familiar with all aspects of the industry discussed in the book and must therefore base any criticisms on those sections with which he is most familiar.

In connection with the production side of the industry a few obvious errors and some omissions have been noticed, *e.g.* on page 12 it is stated that "the first four tons of plantation rubber appeared on the world market in 1910". This is an obvious error for the year 1901, since in the table (4) on the next page, the total output of plantation rubber in 1910 is given as 11,000 tons.

On this same page also, it is stated that the original seedlings developed at Kew were planted in Ceylon and thence distributed to other British possessions in Eastern Asia. It is now well known that some seedlings were sent direct to Malaya.

Again, on page 87 it is stated "that the creaming of latex has been used but little in practice" whereas until quite recently, the amount of creamed latex exported from Sumatra was equal to and probably exceeded the export of centrifuged concentrate from Malaya.

In connection with the "skim latex" from the centrifugal process of concentration it is stated (p 87) that "this is easily coagulated," which is not correct.

In connection with the spontaneous coagulation of latex (pp. 102 and 125) both in the presence or absence of sugars, no mention is made of the fact that this was discovered and practised in Malaya and described first by the present reviewer and his colleagues. In this connection the results of some of the work published by the present reviewer and his colleagues in the Department of Agriculture appear to have been overlooked.

The original author would appear also not to have had access to some of the publications of the Rubber Research Institute of Malaya.

These criticisms however are of a minor character and do not detract seriously from the mass of valuable information contained in the book.

B.J.E.

Kuala Lumpur,

17th July, 1935